No. 25-1087

IN THE UNITED STATES COURT OF APPEALS
FOR THE DISTRICT OF COLUMBIA CIRCUIT

IN RE:
CENTER FOR BIOLOGICAL DIVERSITY, PEOPLE FOR PROTECTING PEACE RIVER, BAYOU CITY WATERKEEPER, HEALTHY GULF, MANASOTA-88, PORTNEUF RESOURCE COUNCIL, RISE ST. JAMES LOUISIANA, SIERRA CLUB, WATERKEEPER ALLIANCE, and WATERKEEPERS FLORIDA,

Petitioners.

PETITION FOR WRIT OF MANDAMUS
APPENDIX OF ATTACHMENTS IN SUPPORT OF PETITION FOR WRIT OF MANDAMUS

VOLUME 3 of 7

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TENORM: Fertilizer and Fertilizer Production Wastes

The most important use of phosphate rock is in the production of phosphate fertilizers. Due to its chemical properties, phosphate rock may contain significant quantities of naturally occurring radioactive materials (NORM):

- Uranium <https://epa.gov/web/20230718102611/https://www.epa.gov/radiation/radionuclide-basics-uranium>
- Thorium <https://epa.gov/web/20230718102611/https://www.epa.gov/radiation/radionuclide-basics-thorium>
- Radium <https://epa.gov/web/20230718102611/https://www.epa.gov/radiation/radionuclide-basics-radium>
- Their decay products

Uranium concentrations in phosphate ores found in the U.S. range from 20 - 300 parts per million (ppm) (or ~0.26 - 3.7 becquerels per gram (Bq/g), which is 7 - 100 picocuries per gram (pCi/g)). Thorium occurs at essentially background levels, between 1 - 5 ppm (or about 0.0037 0.022 Bq/g, which is 0.1 - 0.6 pCi/g).

Before phosphate ore is turned into fertilizer or other products, it is transformed into either phosphoric acid (through a wet process), or elemental phosphorus (through a thermal process). This processing concentrates NORM in the waste products, transforming them into Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM) <https://epa.gov/web/20230718102611/https://www.epa.gov/radiation/technologically-enhanced-naturally-occurring-radioactive-materials-tenorm>.

The United States mines and consumes about 23 million tons of phosphate rock per year, most of it (95%) for wet-process phosphoric acid or super phosphoric acid with the balance used to produce phosphorus compounds for industrial applications, primarily glyphosate herbicide.

On this page:

- Phosphate Fertilizer
- Waste Generation
- EPA's Role

Phosphate Fertilizer

The yearly consumption of phosphate-based fertilizers in the U.S. averaged close to 5.8 million metric tons (MT) between 1960 and 2007, and had increased to over 8.5 million MT by 2007. While phosphate fertilizers are not considered to be waste, they do contain some of the naturally occurring radium (Ra-226) found in phosphate ores.

The concentration of Ra-226 varies from approximately 0.185 - 1.11 Bq/g (5 - 30 pCi/g), depending upon the type of fertilizer blend and the origin of the phosphate rock.

Fertilizer application rates vary depending upon the type of crops and soils. A typical phosphate fertilizer application rate is about 40 kg per hectare (approximately 15 lbs. per acre). Fertilizers are available in over 100 different blends with varying concentrations of nitrogen, phosphorus and potassium. Further data on fertilizer consumption in the U.S. (but without data on radionuclide content) can be found on the Department of Agriculture's website
<https://web.archive.org/web/20230718102611/https://www.ers.usda.gov/data-products/fertilizer-use-and-price.aspx>.

Waste Generation

Phosphate rock (phosphorite) mining is the fifth largest mining industry in the United States in terms of quantity of material mined. In 2019 the total production of phosphate rock in the U.S. was estimated at 23 million metric tons (MT). Most phosphate production leads to the making of fertilizers.

The phosphate industry is concentrated in the southeastern U.S. About 90 percent of domestic production capacity in Florida, North Carolina, and Tennessee. Florida alone accounts for approximately 80 percent of the current capacity, making it the world's largest phosphate producing area. The western U.S. also has a phosphate industry, particularly in Idaho.

The wastes of most concern are the byproducts created during the wet and thermal processing steps of fertilizer production.

Phosphogypsum

Phosphogypsum is the primary waste byproduct of the wet-acid process for producing phosphoric acid. During this process sulfuric acid dissolves phosphate rock creating a solid/liquid mixture (slurry) of phosphoric acid and calcium sulfate (phosphogypsum). The desired phosphoric acid component is separated from the mixture by filtration, leaving phosphogypsum as the waste product.

Side view of phosphogypsum stack

Phosphate production generates huge amounts of phosphogypsum wastes, nearly 48 million MTs in 1988 alone. Industry estimates that 5.2 tons of phosphogypsum is produced for every ton of phosphoric acid. Phosphogypsum has little market value and is transferred as a slurry to waste piles called phosphogypsum stacks. The solid portion of the slurry consolidates while the water pools on the stack's surface. Eventually gypsum is dredged from the pools to build up the edges around the stack forming a reservoir for storing process water. After a stack is completely full, it is graded, covered and seeded for erosion protection.

Phosphogypsum contains appreciable quantities of uranium and its decay products, such as radium-226, due to their presence in phosphate ores. Uranium in phosphate ores found in the U.S. ranges in concentration from 0.26 - 3.7 Bq/g (7 - 100 pCi/g).

During the wet process, radionuclides present in the phosphate ore are selectively separated and concentrated. Around 80 percent of the radium-226 becomes concentrated in the phosphogypsum. Radium concentrations at phosphogypsum stacks range from 0.4 - 1.3 Bq/g (11 - 35 pCi/g).

Stacks are generally constructed on unused land or on mined out areas at production sites with little or no prior preparation of the land. They are not covered with soil or any other material.

There are over 70 identified stacks in the U.S. The stacks are located in Arkansas, Florida, Idaho, Iowa, Illinois, Louisiana, Minnesota, Mississippi, Missouri, North Carolina, Texas, Utah, and Wyoming. Florida has the largest number of stacks among these states. The

stacks are of considerable size ranging from 2 - 324 hectares (800 acres) in surface area and 3 - 60 meters in height.

Stacks are constructed with little or no soil preparation.

Since there are large quantities of phosphogypsum waste, the industry encourages research into potential uses in order to minimize the disposal problem. The greatest use of phosphogypsum is in agricultural applications. Researchers proposing new uses must file an application with EPA.

Phosphogypsum has been used in agriculture as a source of calcium and sulfur for soils that are deficient in these elements. When the phosphogypsum is used as a fertilizer, it is simply spread on the top of the soil. When used for pH adjustment or sediment control, it is tilled into the soil.

The activity of phosphogypsum used for agricultural purposes may not exceed 0.37 Bq/g (10 pCi/g). An estimated 221,000 MT of phosphogypsum are taken from the phosphogypsum stacks and used in agriculture each year. There is no limitation on the amount of material that can be applied and farmers do not have to maintain certificates or application records.

In the past, phosphogypsum was incorporated into a Portland cement mixture for use in road construction. The use of phosphogypsum for such purposes is banned under the EPA final rule issued on June 3, 1992, which amends 40 CFR 61 Subpart R <https://epa.gov/web/20230718102611/https://www.epa.gov/radiation/subpart-r-national-emission-standards-radon-emissions-phosphogypsum-stacks>.

Radon <https://epa.gov/web/20230718102611/https://www.epa.gov/radiation/radionuclide-basics-radon> (Rn-222) can be found emanating from the surface of phosphogypsum stacks. Average radon fluxes range from 0.06 - 0.44 Bq/m^2 (1.7 - 12 pCi/m^2) per second and can be as high as 12.6 Bq/m^2 (340 pCi/m^2) per second, with a mean value of 0.25 Bq/m^2 (6.8 pCi/m^2) per second.

Radiation levels in phosphogypsum vary considerably from stack to stack and from different locations in a single stack due to a number of factors:

- Radium concentration in the phosphate rock.
- Emanation rate.
- Vegetation cover.
- Porosity.
- Moisture content.
- Presence of standing water.
- Temperature/barometric pressure.

Phosphate Slag

Phosphate slag is the principal waste produced from the thermal process for the conversion of phosphate rock to elemental phosphorus. Production of elemental phosphorus, primarily in Idaho, has steadily gone down due to decreasing demand and increasing energy costs associated with its production.

Phosphate slag is a glassy substance created during furnace processing. Because of its physical properties and its high carbonate content, slag is less susceptible to radionuclide leaching than phosphogypsum. However, concentrations of uranium, thorium and radium in phosphate slag have been measured as high as 1.85 Bq/g (50 pCi/g) in some instances.

The average radon measurements emanating from slag piles is just 0.0185 Bq/m^2 (0.5 pCi/m^2) per second. This is relatively low when compared to the radon measurements from native soil samples which range from 0.063 - 0.63 Bq/m^2 (1.7 - 17 pCi/m^2) per second.

Slag is generally stored in waste piles on site at production facilities. It has been reused for a variety of applications:

- Highway construction aggregate (crushed base and crushed aggregate for asphalt).

- Portland cement and concrete (banned by the state of Idaho in 1977 for use in habitable construction).
- Railroad ballast and general construction.

EPA's Role

Because of concerns over elevated radionuclide concentrations in phosphogypsum, the U.S. Environmental Protection Agency issued a final rule on June 3, 1992 amending 40 CFR 61 Subpart R <https://epa.gov/web/20230718102611/https://www.epa.gov/radiation/subpart-r-national-emission-standards-radon-emissions-phosphogypsum-stacks>. It states that phosphogypsum intended for agricultural use must have a certified average concentration of radium-226 no greater than 0.37 Bq/g (10 pCi/g). There is no limitation on the amount of material that can be applied, and farmers do not have to maintain certificates or application records.

EPA also has a National Emissions Standard for Hazardous Air Pollutants (NESHAP) for Po-210 emissions from the thermal process at 40 CFR 61 Subpart K.

Due to concerns over radiation exposure, the State of Idaho has prohibited the use of phosphate slag in the construction of habitable structures since 1977.

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P.2

RM2A-S0009

SUPPLEMENTAL INFORMATION ON PHOSPHORIC ACID PRODUCTION:

ALTERNATIVE MANAGEMENT OF PROCESS WASTEWATER AT PHOSPHORIC ACID FACILITIES

U.S. Environmental Protection Agency
Office of Solid Waste
Special Wastes Branch
Washington, DC

December 1990

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SUPPLEMENTAL ANALYSIS OF PHOSPHORIC ACID PRODUCTION
WASTE MANAGEMENT ALTERNATIVES

1. INTRODUCTION

a. Purpose and Scope

The Environmental Protection Agency (EPA) is currently preparing a Regulatory Determination that will establish whether or not any of the wastes covered in its July 1990 Report to Congress on Special Wastes from Mineral Processing warrant regulation as hazardous wastes under Subtitle C of the Resource Conservation and Recovery Act (RCRA). In order to collect information on the current generation and management of these wastes for the preparation of the Report to Congress (RTC), EPA solicited and received responses from facilities that generate these wastes to a survey, the National Survey of Solid Wastes from Mineral Processing Facilities (SWMPF). EPA supplemented this information with visits to several mineral processing facilities, results of sampling of the special wastes, contacts with state agency personnel, and reviews of the scientific and engineering literature. Together, these sources provided the principal data and information that EPA used to prepare the RTC.

Among the 20 special wastes that are under consideration for the Regulatory Determination, the Agency has conducted additional investigations into the characteristics, generation, and management of two wastes from the wet-process production of phosphoric acid, process wastewater and phosphogypsum. In general, data used in the RTC address the characteristics (e.g., quantities, chemical composition) of process wastewater in aggregate, rather than the characteristics of the wastewaters generated by individual unit operations (e.g., barometric condenser cooling water, phosphogypsum transport water) in the phosphoric acid production process. In addition, available information on the chemical characteristics of process wastewater that was used in the RTC includes any potential effects resulting from the co-management of process wastewater and phosphogypsum, which is standard industry practice.

Data evaluated for the RTC indicate that process wastewater and phosphogypsum contaminant concentrations are such that the wastes may exhibit the hazardous waste characteristics of EP toxicity and/or corrosivity. These data do not indicate, however, the sources of the contaminants in the wastewater, which could include the phosphogypsum or any (or all) of the numerous operations in the phosphoric acid production process that generate process wastewater. As a result, the management option evaluated in the RTC addressed process wastewater in the aggregate. The aggregate process wastewater stream at a phosphoric acid facility is the total quantity of process wastewater that circulates throughout the operations of the facility Individual processes in the production of phosphoric acid, such as the reaction, filtration, and evaporation stages, contribute individual process wastewater streams (also referred to here as "sub-streams") that eventually collect in the facility's cooling pond and collectively are referred to as the special waste "process wastewater". Wastewaters collected in the cooling pond are continually returned to the plant for use in the phosphoric acid production process.

If the primary sources of contaminants in process wastewater include all of the major processes that contribute to the generation of process wastewater, then the approach used in the RTC of evaluating management alternatives with respect to the combined (aggregate) process wastewater stream is appropriate. If, on the other hand, contaminants are introduced to the procéss wastewater by only some of the unit processes used in phosphoric acid production, then it may be appropriate to consider additional waste management alternatives that involve segregated management of some process wastewater sub-streams.

Accordingly, in August 1990, EPA undertook the task of collecting additional data and analyzing the generation and management of process wastewater and phosphogypsum from phosphoric acid operations. EPA decided to undertake this effort for the following reasons:

(1) to gain a better understanding of the sources and characteristics of process wastewater sub-streams that contribute to the aggregate, facility-wide process wastewater stream and to the water balance of a phosphoric acid facility;

(2) to examine the sources and sinks of contaminants within both the process wastewater sub-streams and the aggregate process wastewater as well as within phosphogypsum;

(3) to identify and evaluate available pollution control/waste management technologies that may be combined in several engineering-based, alternative approaches to separately managing some process wastewater sub-streams (that in part expand upon those approaches that were evaluated in the RTC); and

(4) to evaluate the costs of engineering-based alternatives to managing these wastes in addition to those considered in the RTC.

The Agency plans to use the findings of this analysis in combination with the RTC and public comments on the RTC to make the required Regulatory Determination on the RCRA status of process wastewater and phosphogypsum.[1]

This introduction continues with a summary of the activities the Agency undertook to develop the data necessary to conduct this study. The remainder of the document presents an overview of the findings of EPA's information collection activities, descriptions of seven engineering alternatives for the management of process wastewater and phosphogypsum, the estimated capital and annual compliance costs of each engineering alternative for a model phosphoric

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[1] In its analysis of waste management alternatives in the RTC, EPA considered the least-cost option in examining the costs of the alternatives from a compliance perspective. EPA plans to continue using the least-cost approach, but has considered and presented several alternatives (and their associated costs) in this analysis because the least-cost alternative for the model plant examined may not be the least-cost alternative for all phosphoric acid facilities.

acid facility, and a discussion of the findings of the analysis. The report also contains an appendix for each engineering alternative that provides detailed descriptions of required equipment and incremental capital and operating and maintenance costs.

It should be noted that this report is concerned primarily with the technical feasibility and costs of the engineering alternatives; where available and appropriate, the Agency has provided some preliminary conclusions on the cost effectiveness and/or technical merit of one alternative with respect to the others. The report does not, however, include a detailed analysis and assessment of the impacts that these alternatives, if implemented, would have on the phosphoric acid industry or its markets.

b. Approach

The Agency undertook several activities to gather further information regarding the generation and management of process wastewater and phosphogypsum from phosphoric acid operations, including: (1) visits to selected phosphoric acid facilities; (2) review of comments submitted by interested parties in response to the Report to Congress; and (3) review of additional scientific and engineering literature regarding treatment of wastes from phosphoric acid production. These activities are described in the following sections.

i. Site Visits

In order to better understand the phosphoric acid production process and the management of wastes from this process, EPA and its representatives visited six active phosphoric acid facilities during August and September, 1990. During these visits, EPA sought to acquire information that would be useful in developing and analyzing alternatives to current management practices, including:

- additional data on the characteristics of phosphogypsum and phosphoric acid process wastewater;
- details on the flow and recirculation of process wastewater to obtain a more detailed understanding of the water balance;
- information on the contribution of each step in the production process to contaminant concentrations observed in process wastewater and phosphogypsum;
- details of alternative or innovative pollution control measures and waste management practices that might now be in operation, as well as their effectiveness; and
- information about additional related production operations (e.g., fluosilicic acid recovery, uranium recovery) and their impacts on waste characteristics and management.

Ideally, EPA would gather this information by visiting all existing facilities. Given time and cost constraints, however, it was not feasible to visit all 20 active phosphoric acid operations. Instead, EPA selected six sites based, primarily, on the following two factors:

- complexity/simplicity of operation; and
- representativeness of industry-wide production and waste management practices.

To evaluate these factors and apply them to the facilities, EPA relied primarily upon information derived from the RTC and from the National Survey; the Agency supplemented this information, where appropriate, with reviews of other data sources.

In the current context, complexity/simplicity of operation refers to the number and types of discrete products that are manufactured at each facility in addition to merchant grade phosphoric acid, such as fertilizer products and animal feed ingredients; the existence of phosphate rock mining operations on site was also considered. Larger numbers of phosphoric acid-based products and associated production lines implies greater complexity in the overall operation of the plant, as well as the possibility of providing additional sources and sinks of process wastewater contaminants. Moreover, because one of the goals of the visits was to examine details of the flow and recirculation of process wastewater for use in performing a water balance, EPA considered the existence of a wastewater treatment plant at each facility, along with the type of treatment process incorporated and an indication of whether treated process water had been discharged from the plant in 1988 (the year considered in the National Survey).

EPA evaluated representativeness of facilities within the industry by determining each facility's contribution to 1988 total national production of phosphoric acid. EPA then sorted the resulting percentages by region (southeastern, western, and gulf coastal United States) so that geographic representativeness could be determined. This exercise confirmed that the majority of 1988 production (75 percent) was accounted for by the southeast region, primarily by central Florida. The gulf coast region accounted for 17 percent, while the three western facilities produced the remaining eight percent. In addition, five plants accounted for more than half of 1988 production; four of these are in the southeast region, with two in central Florida (Central Phosphate/Plant City and IMC/Mulberry), one in northern Florida (Occidental/White Springs), and one in North Carolina (Texasgulf/Aurora). The remaining plant is in Louisiana (Agrico/Uncle Sam)

EPA's objective in selecting sites to be visited was to capture as much information on typical, or at least representative, phosphoric acid plants as possible, given the Agency's significant time and budget constraints. Accordingly, EPA decided to focus on relatively large facilities in the southeast and gulf coast regions. By selecting and scheduling visits to . . plants carefully, the Agency was also able to conduct one-day visits to . . . smaller, additional plants located in proximity to the larger plants. Th.

facilities that were selected and visited during August and September, 1990 are as follows:

- Texasgulf/Aurora, NC;
- IMC/Mulberry, FL;
- U.S. Agri-Chemicals/Fort Meade, FL;
- Gardinier/Riverview, FL;
- Agrico/Uncle Sam, LA; and
- Agrico/Donaldsonville, LA.

Trip reports describing these field visits are included in Appendix A to this document.

ii. Review of Comments on the Report to Congress

In an effort to identify potential limitations of the waste management options and supporting analyses presented in the Report to Congress (RTC), EPA reviewed written comments submitted on the RTC related to the phosphoric acid industry. In particular, the Agency focused upon potential legal and operational limitations associated with the waste management techniques evaluated for the RTC, and upon waste management issues and costs that the commenters believed had not been fully addressed in the RTC.

iii. Literature Review

In order to better understand the management and characteristics of the two waste streams of interest, EPA conducted a review of the technical literature addressing the wet process phosphoric acid industry. The focus of this inquiry was information on the sources and behavior of chemical contaminants in the process wastewater stream.

2. OVERVIEW OF FINDINGS FROM ADDITIONAL STUDIES

As a result of conducting the activities described above, EPA has been able to significantly expand its understanding of phosphoric acid production wastes, over and above that which was reflected in the RTC. Major findings are discussed below.

a. Sources and Sinks of Contaminants in the Individual Waste Streams

EPA now believes that the acidity and other contaminants that have been observed in process wastewater from phosphoric acid production arise from two primary sources: (1) the filtered phosphogypsum "cake" that is generated immediately downstream of the reactor; and (2) the vapors that are driven from the product stream during flash cooling of the reactor vessel and, subsequently, evaporation (concentration) of the crude product acid. Furthermore, the Agency believes that the source of the dissolved metals in process wastewater that have been observed at some facilities is phosphogypsum, and that the potential for dissolution and release of these metals is greatly increased through the more or less constant exposure of the gypsum to the highly acidic process wastewater that circulates through active

gypsum disposal areas (phosphogypsum stacks) and is returned to the cooling water pond.

As generated, the filtered gypsum generally contains several percent of the raw phosphoric acid product stream, which remains with the gypsum when it is slurried with water and removed to the phosphogypsum stack. This loss of raw phosphoric acid product to the gypsum is the result of inherent inefficiencies in the filtering process that all phosphoric acid facilities employ. Raw product acid contains 25-30 percent phosphoric acid (as P_2O_5), approximately two percent sulfuric acid (which is universally added in excess to the reaction vessel in order to facilitate proper gypsum crystal growth), and one to two percent dissolved fluorine (primarily as fluosilicic acid [H_2SiF_6], which is also referred to as FSA), which enters the production process as a component of the phosphate rock. The raw, unrecovered acid that accompanies the gypsum to the disposal stack is the source of virtually all of the P_2O_5 and sulfuric acid values that may be found in the process wastewater stream of a well-operated plant. The acid contained in the transport water that carries the gypsum to the stack eventually leaches through the stack, collects in ditches that surround the stack, and flows to the cooling pond where it mixes with cooling water to form the aggregate process wastewater stream. Other minor sources of P_2O_5 and sulfuric acid values may include occasional carry-over to the condensers from the reactor and the evaporators and as well as process upsets. (See the Base Plant Block Flow Diagram in Appendix C for an overview of "typical" wastewater generation and recirculation.)

In addition to the filter inefficiencies noted above (intrinsic equipment limitations), EPA has anecdotal evidence that some facility operators run their production equipment (including filters) above its design capacity, in order to maximize throughput and thereby minimize fixed costs per unit of output. To the extent that this practice occurs, contaminant loadings to the process wastewater stream will increase, perhaps significantly, as filter efficiency declines. Obviously, any such additional contaminant loadings would increase the corrosive nature of the process wastewater stream.

Vapors from the reaction and evaporation stages of the production process are cooled and condensed, giving rise to the "cooling water" component of the process wastewater stream. These vapors generally contain relatively high concentrations of fluorine as silicon tetrafluoride (SiF_4). Upon condensation of the vapors to water in flash coolers and barometric condensers, the SiF_4 is converted to H_2SiF_6. This cooling water stream is sent to the cooling pond and is the major source of fluorine (as FSA) to the aggregate process wastewater stream.

In addition, EPA believes that other potentially significant historical contaminant sources include sulfuric acid plant wastewaters and vessel and pipe cleanout wastes. Because these materials have been removed from the Mining Waste Exclusion, EPA does not believe that they will contribute significantly to future contaminant loadings of the process wastewater stream at active facilities.

Process wastewater frequently exhibits the hazardous waste characteristic of EP toxicity. EPA's field visits and subsequent engineering analysis suggest that the observed metals concentrations cannot have resulted from volatilization of metals from the product stream into the vapors that are withdrawn from the reactor and evaporators and that ultimately enter the process wastewater stream as cooling water. The Agency believes, therefore, that the source of these contaminants is the phosphogypsum.

EPA's available waste characterization data indicate that phosphogypsum almost never exhibits the characteristic of EP toxicity; data from only one of eleven plants indicated exceedances of regulatory thresholds. This suggests that when a mildly acidic leaching medium is brought into contact with phosphogypsum, any heavy metals contained within the gypsum are unlikely to be leached out in significant quantities. At a typical phosphoric acid plant, however, the gypsum is brought into contact with highly acidic process wastewater with a pH of less than 2, first at the filter where it is washed and slurried to the disposal unit (i.e., the gypsum stack), and subsequently on the stack with repeated and more or less continuous additions of gypsum slurry and, periodically, cooling water from the reaction and evaporation stages of phosphoric acid production.[2] Accordingly, it is EPA's working hypothesis that if process wastewater and phosphogypsum were to be segregated (i.e., managed separately), or if the gypsum were to be slurried with water and treated to a pH of greater than 2, then phosphogypsum would not exhibit any of the characteristics of hazardous waste and process wastewater would not exhibit the hazardous waste characteristic of EP toxicity. EPA has not been able to validate or refute this hypothesis due to an absence of empirical data, and the Agency solicits comment on this preliminary finding.

In summary, three "contaminants," raw phosphoric and sulfuric acids, and fluosilicic acid, contribute the bulk of the observed acidity of the aggregate process wastewater stream through their introduction to the aggregate stream by the individual gypsum slurry and cooling water sub-streams, respectively. In order to limit or prevent the introduction of these contaminants to the aggregate process wastewater stream, technologies might be employed to either (1) reduce or remove the contaminant concentrations from the sub-streams, or (2) contain the sub-streams in a manner that would prevent or limit the release of their associated contaminants to the environment.

b. Available Pollution Control/Waste Management Technologies and Their Current Applications

Having identified the important sources of the constituents of concern in the two special wastes from phosphoric acid production, EPA investigated and evaluated the following five pollution control/waste management technologies that might reduce, eliminate, or limit the impacts arising from these constituents:

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[2] At many phosphoric acid facilities, a portion of the cooling water is sometimes routed to the phosphogypsum stack in an effort to spatially distribute the heat load of the cooling water and, thereby, effect evaporation and associated cooling.

(1) increased P_2O_5 recovery/decreased water-soluble P_2O_5 loss through increased filter area;

(2) lime neutralization of gypsum slurry and/or cooling water;

(3) fluosilicic acid (FSA) recovery from cooling water;

(4) use of closed-loop heat exchanger system; and

(5) "lined" waste management units.

These technologies fall into two basic categories: 1) systems for reducing contaminant concentrations by removing them from the waste(s) or limiting their entry into the waste(s); and 2) systems for containing the wastes in a manner that would prevent or limit releases of these contaminants to the environment. These two categories can be applied to the five technologies in the following way:

Technologies that Reduce Contaminant Concentrations	Technologies that Contain Wastes and Prevent or Limit Contaminant Release
Increasing filter area	Closed-loop heat exchanger system
Lime neutralization of gypsum slurry and/or cooling water	"Lined" waste management units
Fluosilicic acid recovery	

The following section describes each of these technologies in detail.

i. Increasing Filter Area

In order to separate phosphoric acid from the calcium sulfate crystals (i.e., phosphogypsum) that are created in the reactor, phosphoric acid facilities load the acid/gypsum slurry onto a filter and apply a vacuum to the filter bottom, drawing the product acid through the filter. After the product acid is withdrawn, the gypsum remaining on the filter is washed, typically three times (throughout the industry), in an effort to purge the gypsum cake of as much residual P_2O_5 as possible.[3] Phosphoric acid industry experts have reported to EPA that the amount of residual P_2O_5 that can be removed with more than three washings is minimal relative to the additional effort and cost required. Estimated water-soluble losses of P_2O_5 in the phosphogypsum through filtration can be several percent of the amount of P_2O_5 that is fed to the reactor in the rock slurry; two facilities in Florida have reported losses of approximately two percent and five percent. This water-soluble loss is

[3] Becker, P., 1989, Phosphates and Phosphoric Acid. New York: Marcel Dekker, p. 426.

carried with the phosphogypsum to the stack, where it may eventually leach through the stack.

By increasing the active surface area available for filtration (while maintaining a relatively constant rate of P_2O_5 fed to the reactor), more P_2O_5 product acid can be removed from the acid/gypsum slurry, with a corresponding decrease in the water-soluble loss of product acid to the gypsum that is retained on the filter. This increase in recovery is possible because the additional filter area increases the capacity of the entire filter (i.e., more generated gypsum per ton of P_2O_5 fed to the reactor is exposed to the vacuum and washings, thereby increasing the amount of residual P_2O_5 that can be recovered).

Based on analysis performed on behalf of the Agency by process engineers having extensive phosphoric acid industry experience, EPA has estimated that for a phosphoric acid plant that operates at 1,000 short tons per day (TPD) of P_2O_5 fed to the reactor with an available filter area of 1,111 square feet, the water-soluble loss of P_2O_5 would be approximately 4 percent of the 1,000 tons fed, or 40 TPD. Furthermore, by adding an additional 320 square feet of filter, the water-soluble loss of P_2O_5 may be reduced to 2 percent, or 20 TPD. This decrease in the loss of P_2O_5 to the gypsum would also reduce the acid loading to the stack. Therefore, increasing the filter area may be potentially incorporated as a means of controlling the acidity of the gypsum slurry and, ultimately, the aggregate process wastewater stream.

ii. Lime Neutralization

Because the combined process wastewater stream from all phosphoric acid production processes has been demonstrated to potentially exhibit the hazardous waste characteristic of corrosivity by virtue of its low pH (i.e., frequently below the corrosivity characteristic of pH 2), a potential technique to elevate the pH of the sub-streams (the gypsum transport slurry and the cooling water) is the addition of lime in amounts sufficient to raise the pH above 2.

In order to increase the alkalinity (i.e., raise the pH) of the process wastewater, lime in the form of calcium oxide (CaO, which is often called quicklime) can be used as the reagent. Calcium carbonate ($CaCO_3$, or limestone), which decomposes when heated to form quicklime, may also be used as the reagent in lieu of CaO. In addition to raising the pH of the solution, the reaction also results in the removal of fluorides, phosphates, and other ions such as silicon from solution through precipitation. In general, as the pH rises, fluoride, accompanied by silicon, precipitates first from solution, followed by phosphorus and subsequently sulfates.

The degree to which fluoride (as H_2SiF_6) and phosphate (as H_3PO_4) can be removed from process wastewater through chemical precipitation is a function of four factors:

(1) the initial fluoride (F^-) and phosphate (PO_4^{3-}) concentrations;

(2) the concentration of the precipitating cation, which in this case is the calcium in the quicklime;

(3) the concentrations of other anions that compete with fluoride and phosphate for the precipitating cation (e.g., silicon); and

(4) the pH and overall ionic strength of the process wastewater.

Fluoride can be removed from cooling water by using the first stage of a two-stage lime neutralization process commonly used in the phosphoric acid industry to prepare cooling pond water for discharge from a NPDES outfall when the water balance of a plant is positive. For example, Agrico, Conserv, and Gardinier currently use such treatment processes.

Prior to treatment, process (pond) wastewater typically contains about 6,500 mg/L P and 9,000 mg/L F and has a pH of about 1.5.[4] Stage 1 lime treatment involves neutralization to raise the pH to approximately 3.5 to 4. As the pH increases, the availability of fluoride ions also increases with lime addition. As the fluoride ion concentration increases, calcium fluoride precipitates according to the following reaction:

$$Ca^{++}(aq) \quad + \quad 2F^-(aq) \quad = \quad CaF_2(s)$$

Silica also precipitates according to the reaction:

$H_2SiF_6(l)$ +	$3CaO(s)$ +	$3H_2O(l)$ →	$3CaF_2(s)$ +	$4H_2O(l)$ +	$SiO_2(s)$
fluosilicic acid	lime	water	calcium fluoride	water	silica

At pH of approximately 4, the resulting solution contains approximately 30 mg/L to 60 mg/L F and as much as 5,500 mg/L P.

Stage 2 involves further addition of lime to raise the pH from 4 to greater than 6, at which point calcium compounds (primarily calcium diphosphate as well as more CaF_2) precipitate, primarily through two reactions:

(1)	$2H_3PO_4(l)$ +	$CaO(s)$ +	$H_2O(l)$ →	$Ca(H_2PO_4)_2(s)$ +	$2H_2O(l)$
	phosphoric acid	lime	water	monocalcium phosphate	water

[4] Williams, R.E., 1975, Waste Production and Disposal in Mining, Milling, and Metallurgical Industries. San Francisco: Miller Freeman. p. 168.

(2) $Ca(H_2PO_4)_2(s) + CaO(s) + H_2O(l) \rightarrow 2CaHPO_4(s) + 2H_2O(l)$

monocalcium phosphate	lime	water	dicalcium phosphate	water

The resulting solution has a pH between 6 and 8 and contains 15 mg/L to 30 mg/L F and 30 mg/L to 60 mg/L P. Although Stage 2 primarily removes phosphate from the process wastewater, it also removes other contaminants, such as radium and other metals. The above reactions greatly simplify the actual pond water chemistry, and many other reactions would occur, generating additional precipitates, such as chukhrovite ($Ca_4AlSiF_{13}SO_4 \cdot 10H_2O$) and iron ammonia phosphate ($Fe_3NH_4H_{14}(PO_4)_8 \cdot 4H_2O$).

Although lime neutralization is technically feasible, the target pH for optimum removal of contaminants (without substantial removal of P_2O_5 as calcium phosphate) and to provide a "margin of safety" above pH 2 (the hazardous waste characteristic) has yet to be determined. The specifics of treatment (such as target pH) as well as the effectiveness of treatment will likely differ for new and old waste management units. As described above, most facilities either already utilize lime neutralization or have the capability to employ lime neutralization by augmenting their existing water treatment capabilities.

Several studies have reported on the neutralization of cooling pond water with lime. In a typical laboratory study, calcium oxide or calcium carbonate is gradually added to a sample of cooling pond water. Exhibit 1 presents an example of the amount of lime (in the form of calcium oxide) needed to raise the pH of a pond water sample to 3.5. The chemical composition of the filtrates subsequent to incremental additions of lime are also provided. These data were adapted from a laboratory analysis of pond water neutralization conducted by Occidental Chemical Corporation of White Springs, Florida in November 1990. The results show that from pH 1.41 to pH 3.06, fluoride decreased somewhat from 8,100 mg/L to 5,900 mg/L, while from pH 3.06 to pH 3.50, fluoride decreased dramatically to 45 mg/L as precipitation of CaF_2 increased. The results also show a much smaller decline in the phosphorus concentration (relative to the decline in the fluoride concentration) from 9,690 mg/L at pH 1.41 to 5,720 mg/L at pH 3.50. Similarly, although the sulfate concentration decreased by a factor of one-half from 9,200 mg/L at pH 1.41 to 4,800 mg/L at pH 3.50, the concentration remained high relative to the fluoride concentration. EPA has not assessed the implications of the fact that sulfate concentrations will be changed little if at all by the increase in solution pH from about 1.5 to 3.5

Using an efficiency factor of 85 percent to adjust the results up to a plant-size scale, Occidental estimated that approximately 0.21 pounds of calcium oxide per gallon of pond water would be required to raise the pond water pH to 3.5.

The lime requirements reported by the study do not reflect the buffering effect of sediments likely to be present in an existing cooling pond, which could increase the amount of lime needed to achieve a specific, stable pH for process wastewater contained in an existing cooling pond. In addition, it

EXHIBIT 1

pH AND COMPOSITION OF COOLING POND WATER TREATED WITH LIME

Calcium Oxide Added		pH of Filtrate	Chemical Composition of Filtrate			
(lb/gal)	(mg/L)		P_2O_5 (mg/L)	P (mg/L)	F^- (mg/L)	SO_4^{2-} (mg/L)
0*	0*	1.41	22,200	9,690	8,100	9,200
0.046	5,500	2.04	23,700	10,300	8,400	10,400
0.061	7,300	2.23	23,300	10,200	8,200	8,600
0.075	9,000	2.49	20,300	8,860	6,800	9,700
0.080	9,600	2.65	20,200	8,820	6,600	9,700
0.086	10,000	2.91	14,600	6,370	6,500	9,200
0.090	11,000	3.06	19,400	8,470	5,900	5,000
0.162	19,400	3.20	15,300	6,680	160	9,400
0.176	21,100	3.50	13,100	5,720	45	4,800

*Original pond water.

SOURCE: Occidental Chemical Corporation, Agricultural Products, White Springs, FL, November, 1990.

should be noted that the results of these studies are only applicable to a determination of the amount of lime required to perform a single treatment of pond water and do not reflect the amounts of lime required to treat the acidity added to the water when it is recycled to the process.

Although the elevation of the pH of both the gypsum transport water as well as the cooling water to just slightly above 2 would eliminate the corrosivity characteristic, the incremental addition of acidity with the continual recycle of the aggregate process wastewater stream (which consists of the transport water and cooling water sub-streams) to the reaction, filtration, and evaporation stages of production, as well as pond water chemistry, may tend to push the pH of these sub-streams below pH 2. Therefore, based on analysis performed on behalf of the Agency by process engineers having extensive phosphoric acid industry experience as well as information submitted to the Agency by the phosphoric acid industry, EPA has employed a target pH assumption of 3.5 for analytical purposes; this level should provide both a margin of safety and serve to remove the majority of fluoride from solution. Furthermore, EPA estimates that the additional quicklime required to raise the pH from 2 to 3.5 should not noticeably increase treatment costs, because the majority (as much as 98 percent, according to EPA's analysis) of the total quantity of quicklime used to elevate the pH to 3.5 is expended to raise the pH just to 2.

EPA acknowledges that its estimate that the major expenditure of quicklime comes with the elevation of pH to 2 does not correspond with the results of the Occidental analysis presented in Exhibit 1, in which only 26 percent of the total quicklime demand (required to elevate the sample pH to 3.50) is expended to raise the pH to 2.04. The Agency offers the following possible explanation for this difference: EPA's estimate is based on calculations of equilibria relationships for lime treatment of condensed vapors from the reaction and evaporation stages (i.e., the cooling water sub-stream before it reaches the cooling pond), whereas Occidental's estimate is based on results of a laboratory analysis of lime treatment of pond water (combined process wastewater) collected in its cooling pond. EPA solicits comments on its estimate of quicklime demand, the reason behind the difference between the two analyses, and the resulting implications for the findings of this report.

The use of lime neutralization to treat the process wastewater sub-streams carries with it two important operational effects that ultimately impact the costs of any engineering alternatives that incorporate this technology by reducing the amount of phosphoric acid product generated, and, therefore, proceeds from the sale of the product. Both of these effects are prompted by the additional amount of CaO that would be present in treated sub-streams (approximately twice as much as the pre-treatment level) that are eventually returned as process water to one or more individual unit operations of the phosphoric acid production process. The first effect is the increased tendency for the treated water to form scale whenever

(1) its temperature is reduced (as in pipelines); and

(2) the calcium concentration is increased through production processes, such as evaporation.

The actual incremental amount of scale that would form because of lime treatment and the downtime in production needed for cleaning is difficult to quantify, but EPA has assumed, based on information received from the phosphoric acid industry, that production could be reduced by ten percent due to the associated downtime.[5]

The second effect results from the return of a portion of the treated water to the reactor to aid in the digestion of the rock slurry. Because of the additional quantity of calcium, an additional quantity (beyond what is normally used) of sulfuric acid would be required to buffer the additional alkalinity created by the additional calcium. The reaction of the additional sulfuric acid with the rock slurry would create an additional quantity of gypsum that would require filtration. In order to maintain the same loading of gypsum to the filter to prevent overloading, the amount of phosphate rock fed to the reactor, and ultimately, the amount of phosphoric acid produced would need to be reduced. Again, this reduction would result in lower profit for the facility. In order to account for these operational effects, EPA has included in its cost estimates for the engineering alternatives the losses in production that would result from the use of lime treatment.

iii. Fluosilicic Acid Recovery

Both the reaction and the evaporation (or concentration) stages of phosphoric acid production produce gas effluent. It is possible to recover fluorine from these vapors in the form of a weak fluosilicic acid solution prior to their cooling and subsequent condensation. Once a majority of fluorine is removed from the cooling water sub-stream via FSA recovery, lime treatment, as described above, may be used to remove the remaining fluorine and achieve an acceptable pH.

The following chemical reactions govern the FSA recovery process:[6]

$4HF(l)$	+	$SiO_2(s)$	→ $SiF_4(g)$	+	$2H_2O(g)$
hydrofluoric acid		silica	silicon tetrafluoride		water

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[5] Letter from W. Atwood, Occidental Chemical Corporation, White Springs, FL, to K. Johnson, The Fertilizer Institute, Washington, DC, June 19, 1990

[6] U.S. Environmental Protection Agency, 1979. Source Assessment: Phosphate Fertilizer Industry. Prepared for the Industrial Environmental Research Laboratory, Research Triangle Park, NC by Monsanto Research Corp Dayton, OH. EPA-600/2-79-019c (PB-300 681). pp. 114-116.

$3SiF_4(g)$	+	$2H_2O(l)$	→	$2H_2SiF_6(l)$	+	$SiO_2(s)$
silicon tetrafluoride		water		fluosilicic acid		silica

Hydrogen fluoride and silicon tetrafluoride vapors contained in the effluent dissolve in an aqueous scrubbing solution to form fluosilicic acid.[7]

Two systems for fluosilicic acid recovery are available. The Swenson Evaporation Co. process involves condensation of vapors and flash evaporation to produce an approximately 15 percent solution of fluosilicic acid. The Swift and Co. process uses a weak solution of fluosilicic acid to scrub the fluoride-containing vapors. The solution then flows to a recirculation tank where fluosilicic acid is bled (at about 18 percent to 20 percent concentration) and water (either fresh water or recycled process water) is added to the recycled solution to maintain the required concentration of acid for scrubbing.

The Swift process requires a recovery vessel where scrubbing is accomplished as well as a recirculation tank and recirculation pump (along with associated structures and piping) for each effluent stream. Thus, recovery from all gas effluent entails one set of equipment for the reactor and one set for each evaporation stage (phosphoric acid plants typically have more than one). This process will not recover all of the fluorine from the vapor. Recovery unit exit vapors will still contain fluorine that can be removed in part with the addition of a second stage of recovery equipment; however, based upon calculations of chemical behavior and FSA recovery equipment efficiencies, EPA believes that even with double-stage FSA recovery, exit vapors are likely to contain at least 1,000 mg/L F. Upon condensation, the resulting cooling water would therefore have a pH below 2. Accordingly, lime treatment would be required to remove the remaining fluorides and raise the pH to 3.5, as described in Section 2.ii.(b).

Agrico/Uncle Sam currently recovers fluosilicic acid from six of its eight evaporators using the Swift process. Four of the six Swift towers use clarified river water in the scrubbing solution, while the other two use active pond water. Residual fluoride is not stripped from the recovery unit exit vapors. These exit vapors are condensed and combined with contact cooling water and with condensed vapor from the two evaporators, which utilize no fluorine recovery system, and routed to a NPDES outfall.

The fluosilicic acid that is recovered at Agrico/Uncle Sam is either sold as fluosilicic acid or processed in an on-site plant to produce silicon tetrafluoride gas. The Agrico/Donaldsonville, Agrico/Mulberry, Gardinier/Riverview, Texasgulf/Aurora, and U.S. Agri-Chemicals/Ft. Meade operations also recover fluosilicic acid from their phosphoric acid production

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[7] An alternative method of fluorine recovery is removal of fluosilicate salts prior to concentration of the approximately 30% P_2O_5 acid. One procedure involves addition of sodium carbonate to the filtered solution of weak acid and subsequent precipitation of sodium fluosilicate.

processes. Agrico/Donaldsonville and Agrico/Mulberry both route the recovered fluosilicic acid to an on-site fluorides plant where a product is produced (in the case of Agrico/Donaldsonville, the product is sodium silicofluoride). Gardinier/Riverview sells its recovered fluosilicic acid to municipalities for water fluoridation. Texasgulf sells recovered fluosilicic acid as a product, and U.S. Agri-Chemicals/Ft. Meade sells its recovered fluosilicic acid to an adjacent plant that produces aluminum fluoride.

Although each of the facilities described above have an available market for the fluosilicic acid that it recovers, EPA is aware that industry-wide recovery of FSA would likely create a supply of FSA that would exceed demand, at least in the short term (since new markets could conceivably be created). Given the scope of this analysis, however, the Agency has not attempted to assess the implications of an oversupply of FSA to the market. Where appropriate, EPA has included in its cost estimates for those alternatives that utilize FSA recovery, the credit that the model plant would realize if all FSA recovered could be sold at market value. The Agency acknowledges the questionable validity of this assumption if FSA recovery were to be practiced industry-wide.

iv. Closed Loop Heat Exchanger System

Exit vapors from the reaction and evaporation (or concentration) stages of phosphoric acid production are usually condensed in a barometric condenser (sometimes following an intermediate fluosilicic acid recovery operation). Because these condensed vapors are hot (condensed exit vapor from an evaporator vapor body may have a temperature of 40 degrees Celsius), they are typically routed to an on-site process water pond or lagoon for cooling.

An alternative to the typical cooling process is the use of non-contact cooling water in a heat exchanger/cooling tower system. In this alternative, system heat from the process water (i.e., condensed exit vapors from the fluosilicic acid recovery step) is transferred to cooling water through the use of a heat exchanger or series of heat exchangers. Cooling water never directly contacts the process water and thus is not contaminated. The cooling water is sent to a cooling tower where heat is vented to the atmosphere. The process water will have been cooled and can be directed back into the reaction or filtration stages of the production process or returned to the condenser without the need for an intermediate cooling pond.

This alternative process requires at least one water cooler, consisting of at least one heat exchanger (for example, a shell and tube apparatus) and associated pumps and instrumentation, for each condenser gas effluent stream. In other words, one set of water cooler equipment is required for the reactor and one set for each evaporation stage. Cooling water from all of the heat exchangers may be sent to a single cooling tower, so that only one tower with associated pumps and instrumentation is required for a plant.

v. "Lined" Waste Management Units

This approach parallels that reported in the RTC for managing hazardous and other regulated solid wastes in land-based units. In essence,

contaminants contained within wastes are prevented from escaping into or coming in contact with the environment or potential receptors by the use of impermeable liners, run-on/off controls, caps (at closure), and site access controls.

Cooling Water Ponds

Cooling water at phosphoric acid plants is generally managed in *in situ* clay-lined impoundments; impoundments atop gypsum stacks are used for backup surge capacity. The baseline option assumed for the model plant is a 100-acre, *in situ* clay-lined cooling pond with a 50-acre pond atop the stack. Cooling ponds will continue to be used under most scenarios, with the exception of one scenario that utilizes a closed loop heat exchanger system and a cooling tower.

For engineering alternatives in which cooling water is managed separately from gypsum slurry and transport water, the surge capacity will be met by expansion of the current impoundment rather than by use of the impoundment on top of the stack. The current pond (i.e., 100-acre *in situ* clay-lined) and the expanded 150-acre *in situ* clay-lined pond can only be used to manage waters that are treated so as to not be corrosive (i.e., lime treated to remove the fluorides and raise the pH). Corrosive waters would be managed, where possible, in lined impoundments.

EPA assumes in this analysis that cooling water ponds could not be used to manage untreated corrosive waters under a Subtitle C regulatory scenario, because the recently promulgated land disposal restrictions for corrosive hazardous wastes prohibit the placement of hazardous wastes in surface impoundments unless treatment (removal of the hazardous characteristic) occurs in the impoundment. Moreover, EPA analysis has shown that treatment in surface impoundments is more expensive than treatment in a lime neutralization station prior to discharge to a surface impoundment. Consequently, no cost-effective engineering alternatives are assumed to exist under full Subtitle C for managing untreated cooling waters in solid waste management units.

Under Subtitle C-Minus or D-Plus regulatory scenarios, however, hazardous process wastewater is assumed to be allowed to be managed in a lined impoundment. The Subtitle C-Minus scenario examined here represents the maximum allowable application of regulatory flexibility (e.g., relaxation of liner requirements), just as in the RTC. Under the Subtitle C-Minus scenario cooling water could presumably be managed in a pond with a composite liner (i.e., three feet of recompacted clay overlain by a single synthetic liner). No leachate collection/detection system would be required, but ground-water monitoring wells would have to be installed and sampled regularly. Regulation under the Subtitle D-Plus scenario is assumed to be identical to the Subtitle C-Minus scenario.

Phosphogypsum Stacks

Phosphogypsum generated at all domestic phosphoric acid plants is currently managed in large waste piles, or gypsum stacks. These are typically

lined with *in situ* clay and have no underlying leachate collection systems. Two facilities, however, have indicated to EPA that they are upgrading their phosphogypsum management operations as described below.

- Gardinier's new gypsum stack at its Riverview (Tampa) facility is being constructed with an 18-inch thick recompacted clay liner of local montmorillonitic clay.[8] The stack will be surrounded by a bentonite clay slurry wall and a containment dike 16.5 to 18.5 feet in height. A leachate collection system and a swaled stormwater runoff drainage system will be installed. Eight sets of ground-water monitoring wells are to be installed and monitored; upstream and downstream surface-water monitoring will be conducted as well.

- IMC is planning to expand its gypsum storage area at its New Wales (Mulberry) facility.[9] The expansion will include an earthen perimeter and a 60-mil HDPE liner with perimeter drains over it. A 2.5-foot thick bentonite slurry wall and two culverts will be installed to control seepage, run-off, and decant water. Ground-water monitoring will also be implemented. Side slope stability will be monitored.

The baseline option for the model plant is assumed to be a gypsum stack with a basal area of 150 acres underlain with an *in situ* clay liner. A 50-acre, diked settling pond sits on top of the stack and a toe drain or ditch is assumed to surround the stack to collect leachate or runoff.

Stacks will continue to be used under all engineering alternatives in this study. Under scenarios where the slurry of transport water and gypsum is to be lime treated, the current (i.e., baseline) stack will continue to be used. Under scenarios where the slurry is untreated and is assumed to be corrosive and, therefore, hazardous, the slurry can not go to the baseline stack but must go to a newly constructed multiple-lined gypsum stack. In these cases the old stack would be closed and its leachate collected and managed.

Under Subtitle C regulations, disposal waste piles and, therefore, gypsum stacks, are not permitted. Double composite lined surface impoundments would presumably replace the stacks; this scenario was modeled in the RTC and has not been addressed again in this report. Furthermore, it is not clear that a corrosive slurry could be placed, untreated, in a management unit under the land disposal restrictions. In either case, no Subtitle C option exists in this report for engineering alternatives that do not treat the slurry but use new, lined gypsum stacks to manage the corrosive slurry.

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[8] Information obtained during EPA visit to Gardinier's Riverview, FL facility on September 21, 1990.

[9] Information obtained during EPA visit to IMC's Mulberry, FL facility on September 18, 1990.

Under Subtitle C-Minus or D-Plus regulatory scenarios, on the other hand, untreated corrosive slurry is assumed to be allowed to be managed in a lined gypsum stack. EPA's Subtitle C-Minus scenario, as provided by §3004(x) of RCRA, represents the maximum allowable application of regulatory flexibility and assumes operation of a disposal waste pile for receipt of hazardous waste. Facilities in a high risk-to-ground water area (as the "typical" south Florida facility modeled in this report is considered to be) could operate gypsum stacks with a double synthetic composite liner, leachate collection and detection systems, run-on/run-off controls, and ground-water monitoring.[10] Side slopes of the Subtitle C-Minus gypsum stacks could not exceed a slope of three-to-one so that closure could be performed, including installation of final caps.

Under the Subtitle D-Plus scenario, gypsum stacks would also be allowed. This report's "typical facility" (i.e., in a high risk-to-groundwater area) would operate gypsum stacks with composite liners (i.e., a synthetic liner over a three-foot thick clay liner), leachate collection systems, run-on/off controls, and ground-water monitoring.[11] No side-slope requirements are assumed to exist under Subtitle D-Plus as closure requires no installation of a cap.

<u>Leachate/run-off collection impoundments</u>

Leachate and run-off will always be generated from a phosphogypsum stack in lieu of the enormous effort of a corrective action initiative. EPA believes that the leachate generated within the stack is generally corrosive, though the leachate strength is expected to decline as soon as contaminant loading (emplacement of untreated gypsum slurry or cooling water) ceases. In all engineering alternatives described in this report, a collection pond is included to collect leachate that drains from the base of the stack and rainfall that runs off the stack slopes. These waters are assumed to be collected in an unlined canal that circumscribes the stack, then routed to the cooling pond in baseline scenarios and to the lined collection pond in the compliance scenarios.

Under a full Subtitle C scenario, this corrosive water could be managed only in double-synthetic composite lined surface impoundments. The Subtitle C collection impoundment is lined with a three-foot thick clay liner overlain by two synthetic liners. Between the synthetic liners is a one-foot thick sand layer protected from above by a geonet liner and housing a network of perforated piping for leachate detection/collection. In addition, three-well clusters of ground water monitoring wells would be required around the down-gradient perimeter.

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[10] Facilities in moderate risk areas would have the same alternatives, except that single-lined gypsum stacks would be allowed.

[11] Facilities in moderate risk areas would require a 3-foot thick clay liner with sand and geotextile layers, leachate collection systems, run-on/run-off controls, and ground-water monitoring.

Under Subtitle C-Minus/D-Plus scenarios, ponds constructed with composite liners (three-foot clay overlain by a single synthetic liner) would be used to collect the corrosive leachate and run-off. No leachate collection/detection system would be installed under the pond, but ground-water monitoring wells would be installed and operated.

EPA has assumed, for this analysis, that double-lined surface impoundments could be employed to collect and store the corrosive leachate/run-off under the full Subtitle C scenario, that is, that the Land Disposal Restrictions would not apply to this component of the process wastewater stream. EPA recognizes that this represents a departure from established legal requirements but believes that alternative methods of managing the leachate/run-off (e.g., installing a lime treatment station at the junction of the stack canal and the cooling pond or return ditch to the plant) would be difficult to implement. The Agency has not fully resolved this issue and solicits comment on the legal and technical dimensions of the leachate/run-off management problem.

3. ANALYSIS OF WASTE MANAGEMENT ENGINEERING ALTERNATIVES

EPA has evaluated the five waste management technologies described above individually, and has also analyzed them in combination, in order to develop realistic engineering alternatives to existing phosphoric acid waste management practices. The engineering alternatives have been developed for integrated management of both phosphogypsum and process wastewater at the plant scale and have been applied to a "model" phosphoric acid plant, which EPA has developed for analytical purposes. The analysis consists of identifying the necessary operational changes and new equipment associated with each engineering alternative, the resulting changes in the volume and characteristics of the two waste streams of interest, and the costs that would be incurred by the facility operator.

This section begins with the definition of the model plant, including the specifications and assumptions inherent in its operation. The section continues with a description of the approach EPA took to create the engineering alternatives. The section then presents definitions of the seven engineering alternatives, including descriptions of the operations involved in each alternative (i.e., "how the alternative works") and the capital and annual compliance costs involved in implementing the alternative for the model plant. This section concludes with a discussion of the findings of the analysis.

a. Definition of Model (Design) Plant

The model plant that EPA has employed for this analysis is based upon the data collected in support of the RTC, observations of phosphoric acid production and waste management practices made during site visits, and the expert judgment of process engineers having extensive phosphoric acid industry experience that were retained by the Agency for this purpose.

A block flow diagram of the model plant is presented in Appendix C. The plant operates under the following specifications and assumptions:

Capacity/Rate:	1,000 short tons per day (TPD) P_2O_5 fed to the phosphoric acid plant; rock slurry fed to reactor is 68 percent solids
Filter:	UCEGO rotating table filter, 1,111 square feet (ft^2) of active filtration surface, plant rate/filter area ratio of 0.9 TPD/ft^2
Production:	920 TPD of 54 percent P_2O_5 product acid
P_2O_5 Losses:	4 percent soluble loss at the filter, 4 percent insoluble loss from the reactor, 8 percent loss in total
Contaminant Concentrations:	15:1:1 ratio of P_2O_5:F:SO_4, no other significant contaminants present in the process wastewater
Gypsum Management:	Gypsum is transported from the filter to the stack in a slurry that contains 20 percent solids by weight; stack leachate/run-off is routed to the cooling water pond for eventual recycle to the reaction, filtration, and evaporation stages

As shown in the block flow diagram and in the specifications, the model plant is a simplified, relatively close approximation of production and waste management operations at current phosphoric acid facilities. Rock slurry and sulfuric acid (streams 1 and 2) are combined in the reaction stage to form a reaction slurry of 25-30 percent raw phosphoric acid and gypsum, which is filtered with aggregate process wastewater returned from the cooling pond (stream 9). The filter product acid (stream 5), consisting of 92 percent (920 TPD) of the P_2O_5 introduced in the rock slurry, is sent to the evaporation stage for concentration to the 54 percent, merchant grade phosphoric acid product (stream 7). Vapors from the evaporation stage are cooled, condensed, and routed as cooling water to the cooling water pond (stream 6). Vapors from the reaction stage are also cooled, condensed, and routed to the pond (stream 13). After the gypsum that collects on the filter is purged of as much P_2O_5 as possible, the cake is washed, again with aggregate process wastewater returned from the cooling pond, and pumped as a slurry to the gypsum stack (stream 16). The free water portion of the gypsum slurry leaches through the stack over time, collecting, along with run-off introduced through rainfall, in ditches at the perimeter of the stack. These "transport" waters (stream 15) are conveyed in ditches to the cooling pond to join the cooling water in the aggregate process wastewater stream. Evaporation (stream 8) from the cooling pond liberates the heat contained in the cooling pond water, which is subsequently recycled to the reaction (stream 11), filtration (stream 9), and evaporation (stream 12) stages.

In order to be able to estimate incremental and total costs for the engineering alternatives, EPA first had to establish baseline costs for the model plant. Baseline costs are the costs incurred by the model plant as it operates without the additional expense of the engineering alternatives. Costs for the model plant include capital investment (sunk capital in the

baseline case) and operating and maintenance costs for the gypsum stack and cooling pond used in the model plant; these costs may be combined and expressed as annualized compliance costs (ACC). Before describing these costs, however, EPA presents a definition of each of these terms, including a discussion of how annual compliance cost is calculated.

Annualized Compliance Cost (ACC)

The annualized compliance cost represents the total cost that a facility would incur to operate a given waste management unit during each year of the expected operational life of the unit (assumed here to be just 15 years, as in the July 1990 RTC). Included in the ACC are capital costs, operating and maintenance (O&M) costs, closure costs, and post-closure care costs.

- Capital costs are incurred in year one to construct the waste management unit. These are adjusted for taxes and depreciation, then amortized over fifteen years (a rate of 9.49 percent is used, as in the July 1990 RTC). This annualized capital cost represents the fixed costs associated with constructing and operating a unit.

- Annual O&M costs are the direct costs associated with running a unit each year it is operating; as these costs are already in an annualized form, they are not adjusted prior to inclusion in the ACC.

- Also included in the ACC are closure costs and post-closure care costs (these costs are only estimated for waste management units -- treatment and recovery units incur no closure or post-closure care costs). Costs for closing a compliance (i.e., a Subtitle C, C-Minus, or D-Plus) waste management unit are, in effect, capital costs that are incurred in year 15 to close down a unit. This future cost is discounted to present value and then amortized over the 15-year operating period for inclusion in the ACC.

- Post-closure care (PCC) costs are, in effect, O&M costs incurred from years 15 to 45 (assuming a 30-year post closure care period) for continuing to operate necessary controls (e.g., leachate collection and treatment) or otherwise maintain the closed unit. No PCC costs are incurred for units that are clean closed (i.e., closed with no waste remaining in the unit). PCC costs are discounted to present value then amortized over the 15 years for inclusion in the ACC.

Together these four costs represent the total annualized cost (i.e., fixed, direct, and future costs) of operating a waste management unit over each of the next 15 years.

Given these definitions, baseline capital costs for the model plant 150-acre gypsum stack (basal area) and 100-acre cooling pond, both unlined, are estimated to be approximately $2.3 million and $1.5 million, respectively with operating and maintenance costs of approximately $0.56 million and $0.[illegible] million, respectively. Annualized total baseline costs for the stack and cooling pond are estimated to be approximately $0.9 million and $0.7 million respectively. The estimated total baseline capital, operating and

maintenance, and annualized waste management costs for the model plant are approximately $3.8 million, $1.0 million, and $1.6 million, respectively.

b. **Approach Used to Develop Engineering Alternatives**

To develop realistic and efficacious plant-wide waste management engineering alternatives, EPA has examined the applicability and desirability of each of the five basic pollution control/waste management technologies, as described in Section 2.ii, for managing the two major waste stream components of interest, the phosphogypsum slurry and the cooling waters.

EPA also considered the management of two sub-streams associated with the gypsum slurry and the cooling water that would require some form of treatment and management on implementation of any of the engineering alternatives. The first of these is the leachate/run-off that is generated by all existing gypsum stacks. EPA has assumed here that this material (which has been defined previously as being part of the process wastewater stream) would require active management upon implementation of any of these alternatives. The second is the existing "stock" of cooling water that is held in the pond prior to implementation of an alternative.

In developing the engineering alternatives, EPA sought to apply one and, in some cases, two of the pollution control/waste management technologies to (1) reduce or remove the contaminant concentrations from a sub-stream (e.g., by using lime neutralization alone or in conjunction with FSA recovery), or (2) contain the sub-stream in a manner that would prevent or limit the release of its associated contaminants to the environment (e.g., disposal of the sub-stream in a lined waste management unit). In alternatives in which the sub-stream is treated to remove or reduce contaminant concentrations, the treated sub-stream would be disposed of in an unlined waste management unit, because the treatment step would render the sub-stream "non-hazardous" (e.g., would elevate the pH above 2), removing the need to limit or prevent the release of the sub-stream to the environment (at least from a regulatory standpoint). In alternatives in which treatment is not employed, the sub-stream would be disposed of in waste management units that would meet a level of protection defined by regulatory scenario (e.g., Subtitle C-Minus/D-Plus). Combinations of waste stream components/management technologies that are technically infeasible or that would produce minimal changes in waste stream characteristics or volumes were not considered further.

Given these constraints, EPA developed the following seven engineering alternatives:

Engineering Alternative 1:	Treat slurry and cooling water
Engineering Alternative 2:	Treat slurry and recover FSA/treat cooling water
Engineering Alternative 3:	Construct lined stack and lined cooling pond

Engineering Alternative 4: Construct lined stack and treat cooling water

Engineering Alternative 5: Construct lined stack and recover FSA/treat cooling water

Engineering Alternative 6: Treat slurry and construct lined cooling pond

Engineering Alternative 7: Treat slurry and recover FSA/closed-loop system

Exhibit 2 presents a matrix that indicates the method of managing the gypsum slurry and the cooling water utilized in each alternative. For example, in Engineering Alternative 2, the gypsum slurry would be lime treated to a pH of approximately 3.5 and managed in the usual manner, that is, in the existing gypsum stack, while fluosilicic acid would be recovered from the cooling water with supplemental lime treatment and management in the existing cooling pond. For those alternatives in which the gypsum slurry and/or the cooling water would not be treated (e.g., Alternatives 3, 4, 5, and 6), the waste(s) would be managed in a new lined solid waste management unit meeting the specifications outlined above in Section 2.ii.(2). Note that for those alternatives that feature treatment of the slurry and/or the cooling water, management of the waste subsequent to treatment would be required but would occur in unlined (existing) solid waste management units rather than lined units. For example, in Engineering Alternative 1, the gypsum slurry and the cooling water would be lime treated individually to pH 3.5 and managed in the usual manner, that is, in an unlined gypsum stack and in an unlined cooling pond, respectively.

EXHIBIT 2

METHODS OF MANAGING COOLING WATER AND GYPSUM SLURRY BY ENGINEERING ALTERNATIVE (1-7)

MANAGEMENT METHOD	Treat Cooling Water	Recover FSA Treat Cooling Water	Manage* Cooling Water	Recover FSA Closed Loop
Treat Gypsum Slurry	1	2	6	7
Manage* Gypsum Slurry	4	5	3	NA

* Management occurs in a lined solid waste management unit.

c. **Definitions of Selected Engineering Alternatives**

In this section, we define each of the seven engineering alternatives for alternative management of process wastewater and phosphogypsum outlined above that were selected for analysis of the 1,000 TPD P_2O_5 model plant. For each engineering alternative, EPA presents the following:

- a conceptual description of the alternative, including the basic equipment and waste management units required for the alternative as well as the intended disposal and/or reuse of any solids or effluent generated by the alternative; and

- a description of the incremental and total capital and annual compliance costs of the alternative, including an exhibit presenting these costs.

Engineering Alternative 1: Treat slurry and cooling water[12]

<u>Description</u>

Engineering Alternative 1 would treat cooling and condensed waters[13] from both the phosphoric acid reaction and evaporation stages to a pH of approximately 3.5 through a single quicklime treatment in a neutralization/mixing basin (Block Flow Diagram [BFD] 1).[14] The gypsum slurry that leaves the filter would also be treated, separately from the cooling and condensed waters, with a quicklime slurry to a pH of approximately 3.5 in the gypsum slurry tank that exists in all phosphoric acid facilities (as well as in the model plant). The lime slurry used to treat both the condensed and cooling waters and the gypsum slurry would be prepared in a lime receiving and slaking unit; individual lime slurry streams would be sent from there to the basin and to the tank.

As stated earlier, two compliance options exist for managing slurried gypsum: 1) place the untreated slurry in a lined gypsum stack, or 2) treat the slurry to raise the pH and then place it in the existing stack, which would occur under this Engineering Alternative. Within this alternative there exist two sub-options, only one of which will be cost-effective. The first option is to treat the slurry as it is assumed to be generated at the typical plant (i.e., with four percent soluble P_2O_5 losses on the filter). The second

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[12] Engineering Alternative 1 proposes to lime treat the cooling water, gypsum slurry, leachate/runoff from the existing gypsum stack, and the existing cooling pond.

[13] The term "cooling and condensed waters" is used here to denote condensed vapors from both the phosphoric acid reaction stage and the evaporation stage. Fume scrubber water is also included.

[14] Block flow diagrams for each engineering alternative are presented in Appendix C to this document.

option is to install additional filtration to reduce the amount of acid in the slurry, increase the recovery of P_2O_5, and reduce the amount of lime needed to treat the slurry before discharge to the existing stack. EPA's cost analysis for evaluating which of these two sub-options will be the least cost alternative is shown below.

Use Extra Filtration, then Treat Slurry		
Filter Capital Cost	$2,151,800	
Filter Operating and Maintenance Cost	1,394,100	
Annualized Compliance Cost for Filter		$1,717,200
Quantity of P_2O_5 recovered	20 TPD	
Net value of the P_2O_5	300 $/ton	
Annual Credit for P_2O_5 recovered		($2,190,000)
Treat gypsum, cooling water, CWP	7,125,900	
Net Savings in Lime Treatment O&M	(445,000)	
Annual Cost for Lime Treatment		$6,680,900
TOTAL ANNUALIZED COST FOR FILTRATION THEN TREATMENT		$6,208,100
TOTAL ANNUALIZED COST FOR TREATMENT WITHOUT FILTRATION		$7,125,900

Based on the costs as presented above, the total annualized net cost of adding additional filtration, recovering additional product acid, and then treating the slurry at a reduced rate is lower than the cost of treating the slurry without additional filtration.

The analysis is based on several assumptions, including the assumption that the net profit on the additional acid is 100 percent of the sale price. While some additional production costs from evaporation, clarification, and handling the additional recovered acid would be incurred, EPA was unable to accurately assess these costs for the present study. It is clear, however, that no additional costs would be incurred from the use of additional phosphate rock, sulfuric acid, or electricity (the major variable costs),[15] which at a typical phosphoric acid plant in 1989 accounted for about 65 percent of the approximate 1989 sales price of $300 per ton of 54 percent (agricultural merchant grade) phosphoric acid.[16] Hence, at the very least, approximately $195 per ton of the P_2O_5 recovered would be profit. At $195 per ton the credit for P_2O_5 recovered is $1.4 million annually and the total cost for the filtration/treatment option is $6.97 million annually. The filtration/treatment option, therefore, is still less costly than the treatment without filtration option (at $7.1 million annually). Accordingly,

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[15] The Fertilizer Institute, 1990. Production Cost Surveys for the Year Ended December 31, 1989. Compiled by the National Fertilizer and Environmental Research Center, Muscle Shoals, AL, p. 28.

[16] Chemical Marketing Reporter, December 25, 1989, 236(26):32. Prices per ton of merchant grade phosphoric acid fluctuated around $300 during ...

EPA has included additional filtration for any alternative in which the gypsum slurry is to be treated.

On implementation of the engineering alternative, both leachate/run-off from the existing gypsum stack and cooling water held in the existing cooling pond would require lime treatment. Treatment of the existing cooling water is assumed to be achieved during the first year (i.e., after Alternative 1 is implemented) by continual recycle to the reaction and evaporation stages (see BFD 1) where the water would join with the aggregate cooling water stream, which would then be lime treated as described above. Similarly, treatment of the existing gypsum stack leachate/run-off to pH 3.5 is assumed to be achieved by continual recycle to the filtration stage, where it would be used along with previously treated transport water to filter and wash gypsum. Portions of the existing leachate/run-off would also be used to slurry the gypsum from the filter to the gypsum tank, where the slurry would be lime treated. Unlike the existing cooling pond water, however, the existing stack leachate/run-off is assumed to require treatment for 15 years to reach pH 3.5 because (1) the total volume of leachate is estimated to greatly exceed that of the existing cooling pond water, and (2) release of leachate from the existing gypsum stack (dewatering) is assumed to require 15 years.[17]

Effluent from the neutralization mixing basin, consisting of cooling water at pH 3.5 and calcium fluoride (CaF_2) sludge generated by the lime treatment, would be routed first to an unlined sludge disposal surface impoundment, where as much settling of the sludge as possible would be allowed to occur. Decanted cooling water of pH 3.5 would flow from this impoundment to the existing cooling pond for cooling.[18]

Effluent from the gypsum tank, consisting of the treated gypsum slurry (and some portion of the existing stack leachate/run-off) with a pH of approximately 3.5, would be pumped to the existing gypsum stack. Because the free water volume of the treated gypsum slurry would be larger than that of the pre-treatment slurry by approximately 240 gallons per minute due to the addition of the lime slurry, an additional 50 acres would be required at the top of the gypsum stack to hold the resulting increase in ponded transport water; however, there is expected to be no additional cost incurred to expand

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[17] EPA assumes here that leachate and run-off exhibiting the hazardous waste characteristic of corrosivity will continue to be generated irrespective of management practices for a period of 15 years. The Agency acknowledges that the period during which this would actually occur is likely to be variable on a site-specific basis and cannot be predicted with accuracy for any existing facility.

[18] EPA assumes in this analysis that sufficient settling of the CaF_2 sludge would occur in the surface impoundment and that decanted cooling water of pH 3.5 could then flow to the existing cooling pond for cooling. EPA acknowledges, however, that the characteristics of CaF_2 sludge, which is 70 to 80 percent water and has a very fine-grained consistency, may limit the degree to which settling would occur in the impoundment.

the gypsum stack because the additional acreage would be created through normal grading operations on top of the stack.

Leachate/run-off from the gypsum stack would be captured in a new 50-acre stack leachate/run-off pond and returned to the gypsum filter to recover entrained P_2O_5 product. Because the leachate will generally be corrosive over the 15 years that treatment of the existing leachate occurs, lined impoundments would be required. Engineering Alternative 1A would require installation of a stack leachate/run-off impoundment that meets the Subtitle C criteria outlined in Section 2.ii.5, while Engineering Alternative 1B would mandate installation of a Subtitle C-Minus/D-Plus impoundment.

These impoundments would require operating permits and environmental impairment liability (EIL) insurance. Permit costs are assumed to occur in year one, when the facility opens a Subtitle C, C-Minus, or D-Plus waste management unit, and in years five and ten when the permit is renewed. These three payments have been discounted to present value (i.e., year one), added together, and then annualized over the fifteen year life of the unit; this annualized cost is added to O&M and hence directly to the annualized compliance cost (ACC). Permit costs for Subtitle C and C-Minus units are the same; permit costs for Subtitle D-Plus units are less. The EIL costs are yearly insurance premiums and, as an annually incurred cost, are added to the total O&M and, hence, the ACC. Additional information concerning these costs can be found in the July 1990, Report to Congress on Special Wastes from Mineral Processing Facilities, and supporting technical background documents.

Because the gypsum tank and the neutralization mixing basin would be considered elementary neutralization units used to treat the gypsum slurry and the cooling and condensed waters, respectively, these units would be exempt from requirements for treatment, storage, and disposal facilities (TSDFs) under RCRA Subtitle C (40 CFR 264.1(g)). Furthermore, in a full Subtitle C scenario, Engineering Alternative 1 would afford treatment to a level equivalent to BDAT for corrosive wastes.

<u>Capital and Annualized Compliance Costs</u>

Results of the cost impact analysis for Engineering Alternative 1 are presented in Exhibit 3. The incremental annualized compliance cost (ACC) is expected to be $14.8 million if a Subtitle C stack leachate/run-off pond is assumed; when costs for baseline operations that will continue are included, the total annualized compliance cost is $16.4 million. If a Subtitle C-Minus/D-Plus stack leachate/run-off pond is assumed, then the incremental annualized compliance cost is expected to be $13.7 million. The total annualized operating cost, including costs for baseline operations, is $15.3 million. The incremental capital required in year one to install the Subtitle C alternative is estimated to be $24.6 million. The incremental capital required for the installation of the Subtitle C-Minus/D-Plus alternative is estimated to be $18.3 million. Approximately $3.8 million in capital is already invested in the baseline gypsum stack and cooling pond that will continue to be operated.

EXHIBIT 3

INCREMENTAL COSTS FOR ENGINEERING ALTERNATIVE 1 (C) (Treat Slurry and Cooling Water) (in $ thousands)		
UNIT	**CAPITAL**	**ACC**
Lime Treatment	2,986.9	7,124.9
Additional Filtration	2,151.8	(917.8)
Acid Losses	0.0	4,038.1
CaF_2 Sludge Disposal Impoundment	2,126.1	699.1
Stack Leachate/Runoff Pond	17,286.3	3,509.4
Permits and EIL	0.0	337.0
Total Incremental Costs	24,551.1	14,790.7
Total Costs (incl. baseline costs for cooling pond and stack)	24,551.1	16,381.4

INCREMENTAL COSTS FOR ENGINEERING ALTERNATIVE 1 (C-/D+) (Treat Slurry and Cooling Water) (in $ thousands)		
UNIT	**CAPITAL**	**ACC**
Lime Treatment	2,986.9	7,124.9
Additional Filtration	2,151.8	(917.8)
Acid Losses	0.0	4,038.1
CaF_2 Sludge Disposal Impoundment	2,126.1	699.1
Stack Leachate/Runoff Pond	11,042.8	2,385.9
Permits and EIL	0.0	337.0
Total Incremental Costs	18,307.6	13,667.2
Total Costs (incl. baseline costs for cooling pond and stack)	18,307.6	15,257.9

As seen in Exhibit 3, the ACC for this scenario is composed primarily of the lime treatment and the acid losses costs (expected primarily from scaling due to the higher pH and the calcium load in the treated water) that are expected to drive up costs by more than $7 million and $4 million per year, respectively.[19] It should be noted that lime consumption under Engineering Alternative 1 is the highest of the seven alternatives considered here, because all sub-streams (i.e., gypsum slurry, cooling water, existing stack leachate/run-off, and the existing cooling pond water) require treatment.[20] The stack leachate/run-off pond is also a significant contributor to the ACC, at a cost of over $3 million per year.

Engineering Alternative 2: Treat slurry and recover FSA/treat cooling water[21]

Description

As in Engineering Alternative 1, Engineering Alternative 2 would treat the gypsum slurry with quicklime to a pH of approximately 3.5 in the gypsum tank (BFD 2). Fluosilicic acid (FSA) would be recovered from vapors derived from both the phosphoric acid reaction and evaporation stages. Cooling and condensed waters that result from condensation of the scrubbed vapors following FSA recovery would have as much as 1,000 mg/l F and would have a pH less than 2; therefore, once FSA is removed, the cooling and condensed waters would be lime treated in a neutralization mixing basin to remove the remaining fluorides and to raise the pH to approximately 3.5. As in Engineering Alternative 1, the lime slurry used to treat both the condensed and cooling

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[19] Additional costs due to acid losses result from (1) loss in production due to downtime associated with cleaning of additional scale resulting indirectly from lime treatment, (2) additional sulfuric acid required to buffer the additional alkalinity in the treated water returned to the reactor, and (3) the reduction in acid production due to the additional gypsum created by the additional sulfuric acid. EPA has assumed that these costs would be constant for all engineering alternatives that incorporate lime treatment, but it acknowledges that costs due to acid losses may be lower for those alternatives that also incorporated FSA recovery and/or a closed loop cooling system.

[20] The lime demands for the individual streams that would be treated in Engineering Alternative 1 are 27 TPD for the gypsum slurry, 129 TPD for the cooling water, 34 TPD (over 15 years) for the existing stack leachate/run-off, and 82 TPD (over one year) for the existing cooling pond water. Additional detail on the operating and maintenance costs for lime treatment is included in the appendices.

[21] Engineering Alternative 2 proposes to lime treat the gypsum slurry, gypsum stack leachate/run-off, and existing cooling pond, and recover fluosilicic acid (FSA) from the cooling water with supplemental lime treatment.

waters and the gypsum slurry would be prepared in a lime receiving and slaking unit; individual lime slurry streams would be sent from the unit to the mixing basin and to the gypsum tank.

FSA can be recovered through a single-stage or a double-stage process. (A detailed discussion of the equipment required for FSA recovery is provided in Appendices B-2a and B-2b.) In single-stage recovery, 68 TPD of FSA containing 54 TPD of fluorine (F) as FSA (79 percent of the F in the reactor and evaporator vapors) would be recovered in the 1,000 TPD P_2O_5 plant. A double-stage FSA recovery system would recover an additional 16 TPD of FSA and 13 TPD of F as FSA (79 percent of the remaining F (as FSA)) from the reactor and evaporator vapors for total recoveries of 84 TPD and 67 TPD, respectively. Assuming the existence of a market for sale of the recovered FSA, the sale could be credited to the cost of Engineering Alternative 2, thereby reducing the total cost of the alternative. As discussed below, EPA has estimated that if an adequate market for recovered FSA exists and remains stable, double-stage FSA recovery would be the most cost-effective alternative.

On implementation of Engineering Alternative 2, both leachate/run-off from the existing gypsum stack as well as cooling water held in the existing cooling pond would be lime treated in the same manner as described in Engineering Alternative 1.

As in Engineering Alternative 1, effluent from the neutralization mixing basin, consisting of cooling water at a pH of approximately 3.5 and CaF_2 solids from the lime treatment would be routed to an unlined sludge disposal surface impoundment, where as much settling of the sludge as possible would be allowed to occur; decanted cooling water of pH 3.5 would flow from this impoundment to the existing cooling pond for cooling. The sludge disposal surface impoundment for Engineering Alternative 2 would be smaller than the impoundment required for Engineering Alternative 1, because the estimated annual volumes of settled sludge that would result from lime treatment of defluorinated, condensed waters from single-stage or double-stage FSA recovery would be approximately 40 acre-feet and 6.5 acre-feet, respectively, as compared to 180 acre-feet for Engineering Alternative 1.

As in Engineering Alternative 1, effluent from the gypsum tank, consisting of the treated gypsum slurry (and some portion of the existing stack leachate/run-off) with a pH of approximately 3.5, would be pumped to the existing gypsum stack; an additional 50 acres would also be required at the top of the stack for this alternative, with the cost carried by the baseline management unit (i.e., at no incremental cost).

Leachate/run-off from the gypsum stack would be captured in a new 50-acre stack leachate/run-off pond and returned to the gypsum filter to recover entrained P_2O_5 product. Engineering Alternative 2 (C) would require an impoundment that meets the Subtitle C criteria outlined in Section 2.ii.5. while Engineering Alternative 2 (C-Minus/D-Plus) would require a Subtitle C-Minus/D-Plus impoundment. These impoundments would require operating permits and environmental impairment liability (EIL) insurance.

Capital and Annualized Compliance Costs

Results of the cost impact analysis for Engineering Alternative 2 are presented in Exhibit 4. If the assumption is made that there is no credit from the sale of fluosilicic acid, the incremental annualized compliance cost (ACC) is expected to be $12.5 million if a Subtitle C stack leachate/run-off pond is assumed. When costs for baseline operations that will continue to be operated are included, the total annualized cost is $14.1 million. If a Subtitle C-Minus/D-Plus stack leachate/run-off pond is constructed and no FSA sales credit is assumed, the incremental annualized compliance cost is estimated to be $11.4 million, and the total annualized management cost including baseline costs is approximately $13.0 million. If, however, the FSA sales credit is assumed to be $100/ton of FSA, then the incremental annualized compliance cost of this alternative with a Subtitle C stack leachate/run-off pond is estimated to be $9.5 million, and the total annualized cost including baseline costs is $11.1 million. If a C-Minus/D-Plus stack leachate/run-off pond is constructed and the FSA sales credit is $100/ton, then the incremental annualized compliance cost is approximately $8.3 million, and the total annualized management cost including baseline costs is $9.9 million. The incremental capital required in year one to install the Subtitle C alternative is estimated to be $30.5 million. For the Subtitle C-Minus/D-Plus alternative, the incremental capital required in year one is approximately $24.3 million. Approximately $3.8 million in capital is already invested in the baseline gypsum stack and cooling pond that would continue to be operated.

As seen in Exhibit 4, the ACC for this alternative is due primarily to the lime treatment and FSA recovery systems, the stack leachate/run-off pond, and the acid losses (expected primarily from scaling due to the higher pH and the calcium load in the treated water) that are expected to drive up costs by more than $3.1, $2.2, $3.5, and $4 million per year, respectively. Double-stage FSA recovery is the most cost-effective option for this Engineering Alternative assuming that FSA markets remain stable and a price of $100 per ton can be maintained. This assumes a credit of over $3.0 million that offsets a significant portion of the actual costs. Should markets fall, and the acid be priced at as low as $35 dollars per ton, the single-stage FSA recovery option (see Appendix B-2a) becomes the least-cost alternative. Assuming, however, that Subtitle C-Minus or D-Plus impoundment could be used to manage corrosive cooling waters (see Alternative 6), this $35 per ton FSA price threshold would never be reached as, below $90 per ton for FSA, the most cost effective alternative would not be treatment or FSA recovery, but management in a lined impoundment.

EXHIBIT 4

INCREMENTAL COSTS FOR ENGINEERING ALTERNATIVE 2 (C)
(Treat Slurry and Recover FSA/Treat Cooling Water)
(in $ thousands)

UNIT	CAPITAL	ACC
Lime Treatment	2,986.9	3,080.9
Additional Filtration	2,151.8	(917.8)
Double-Stage FSA Recovery *	7,872.0	2,208.0
Acid Losses	0.0	4,038.1
CaF_2 Sludge Disposal Impoundment	199.8	276.4
Stack Leachate/Runoff Pond	17,286.3	3,509.4
Permits and EIL	0.0	337.0
Total Incremental Costs	30,496.8	12,532.0
Total Costs (incl. baseline costs for cooling pond and stack)	30,496.8	14,123.7

FSA Sales Credit (at $100/ton of FSA)	0.0	(3066.0)
Total Incremental Costs	30,496.8	9,466.0
Total Costs (incl. baseline costs for cooling pond and stack)	30,496.8	11,057.7

EXHIBIT 4 (continued)

INCREMENTAL COSTS FOR ENGINEERING ALTERNATIVE 2 (C-/D+)
(Treat Slurry and Recover FSA/Treat Cooling Water)
(in $ thousands)

UNIT	CAPITAL	ACC
Lime Treatment	2,986.9	3,080.9
Additional Filtration	2,151.8	(917.8)
Double-Stage FSA Recovery *	7,872.0	2,208.0
Acid Losses	0.0	4,038.1
CaF_2 Sludge Disposal Impoundment	199.8	276.4
Stack Leachate/Runoff Pond	11,042.8	2,385.9
Permits and EIL	0.0	337.0
Total Incremental Costs	24,253.3	11,408.5
Total Costs (incl. baseline costs for cooling pond and stack)	24,253.3	13,000.2

FSA Sales Credit (at $100/ton of FSA)	0.0	(3066.0)
Total Incremental Costs	24,253.3	8,342.5
Total Costs (incl. baseline costs for cooling pond and stack)	24,253.3	9,934.2

* The decision to use double-stage recovery is based on the assumption that the FSA sales price is $100/ton

Engineering Alternative 3: Construct lined stack and lined cooling pond[22]

Description

Engineering Alternative 3 would, in lieu of treating all process wastewater and gypsum slurry, manage both wastes in environmentally protective lined waste management units that would meet appropriate waste management standards as defined in EPA's regulatory compliance scenarios (BFD 3). This would require construction of a new composite-lined 100-acre cooling pond and a new 150-acre multiple-lined gypsum stack designed to contain all leachate and run-off.

With the activation of the new units, the gypsum slurry in its current form (i.e., untreated, no additional filtration) would be placed on the new stack. Water in the settling pond on top of the stack (e.g., transport water, rainfall) would be collected via decantation, rainfall run-off would be collected via lined ditches, and leachate would be collected via leachate collection systems built under the stack and over the stack liners.

These combined waters would be captured in a new 50-acre stack leachate/run-off pond and returned to the gypsum filter to recover entrained P_2O_5 product. Because the leachate will generally be corrosive over the 15 years that treatment of the existing leachate occurs, lined impoundments would be required. Engineering Alternative 3A would require installation of a stack leachate/run-off impoundment that meets the Subtitle C criteria outlined in Section 2.ii.5, while Engineering Alternative 3B would mandate installation of a Subtitle C-Minus/D-Plus impoundment.

Also with the activation of the new units, the cooling water in its current form (i.e., untreated) would be placed in the lined cooling pond. Water in the existing pond would not be treated but instead would be pumped either into the plant as the primary feed for cooling requirements, or into the new lined cooling pond for storage before reuse. Once the existing pond had been drawn down, it would no longer be used for corrosive cooling water; the cooling water system would be "closed" with heated water being discharged to the pond and being recycled after cooling from the pond to the plant.

Because full Subtitle C regulations prohibit the use of disposal waste piles and, hence, phosphogypsum stacks, EPA has assumed that this engineering alternative cannot be used to comply with Subtitle C requirements. Differing scenarios exist for meeting potential Subtitle C-Minus and Subtitle D-Plus requirements. The primary difference between the assumed practices for the two regulatory scenarios is that under Subtitle C-Minus the stack must be capped at closure, requiring modification of the stack side slopes to allow a slope angle that can be successfully capped. The Subtitle D-Plus requirements are assumed to not require capping at closure, so the Subtitle D-Plus stack

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[22] Engineering Alternative 3 proposes to construct a new gypsum stack, cooling pond, and collection ditches, all with liners, and reuse, then lime treat leachate/run-off from the existing gypsum stack.

has steeper sides and, therefore, less basal area. This smaller basal area means less liner material is needed; in addition, fewer liners are assumed to be required under the D-Plus scenario (a three foot clay liner overlain by one synthetic liner, on top of which is a leachate collection system). The Subtitle C-Minus stack is assumed to require an additional synthetic liner (for a total of two) and an additional leachate collection/detection system. Both programs would require ground water monitoring.

The lined cooling pond and the stack leachate/run-off pond in either regulatory scenario would require composite liners (i.e., a three foot clay base overlain with a synthetic liner). No leachate collection/detection systems are employed; groundwater monitoring is, however, required for each pond to detect any liner failure.

Capital and Annualized Compliance Costs

Results of the cost impact analysis for Engineering Alternative 3 are presented in Exhibit 5. The incremental annualized compliance cost (ACC) is expected to be $22.1 million if a Subtitle C-Minus stack is constructed, and $15.5 million if a Subtitle D-Plus stack is constructed. The total annualized compliance cost, including baseline costs, is $22.9 million under the Subtitle C-Minus scenario, and $16.3 million under a Subtitle D-Plus scenario. The incremental capital required in year one to implement this alternative is estimated to be $115.1 and $81.2 million under Subtitle C-Minus and D-Plus scenarios, respectively.

As seen in Exhibit 5, the majority of the ACC for this scenario is due to the cost of constructing and operating the gypsum stack (69 percent of total incremental ACC for Subtitle C-Minus and 57 percent under D-Plus).

Engineering Alternative 4: Construct lined stack and treat cooling water[23]

Description

Under Engineering Alternative 4, a facility would manage its gypsum slurry and its cooling water completely separately (BFD 4). As in Engineering Alternative 1, cooling and condensed waters[24] from both the phosphoric acid reaction and evaporation stages would undergo quicklime treatment to a pH of 3.5 in a neutralization mixing basin. The lime slurry used to treat both of these wastewaters would be prepared in a lime receiving and slaking unit and sent from there to the mixing basin.

[23] Engineering Alternative 4 proposes to construct a new, lined gypsum stack and lime treat the cooling water, the existing cooling pond, and leachate/run-off from the existing gypsum stack.

[24] The term "cooling and condensed waters" is used here to denote condensed vapors from both the phosphoric acid reaction stage and the evaporation stage. Fume scrubber water is also included.

EXHIBIT 5

INCREMENTAL COSTS FOR ENGINEERING ALTERNATIVE 3 (C-) (Construct Lined (Subtitle C-Minus) Stack and Lined Cooling Pond) (in $ thousands)		
UNIT	CAPITAL	ACC
100-Acre Cooling Pond	20,097.0	4,048.6
Lined Gypsum Stack	83,985.2	15,360.0
Stack Leachate/Runoff Pond	11,042.8	2,385.9
Permits and EIL	0.0	337.0
Total Incremental Costs	115,125.0	22,131.5
Total Costs (including baseline costs for cooling pond)	115,125.0	22,936.3

INCREMENTAL COSTS FOR ENGINEERING ALTERNATIVE 3 (D+) (Construct Lined (Subtitle D-Plus) Stack and Lined Cooling Pond) (in $ thousands)		
UNIT	CAPITAL	ACC
100-Acre Cooling Pond	20,097.0	4,048.6
Lined Gypsum Stack	50,072.2	8,845.0
Stack Leachate/Runoff Pond	11,042.8	2,385.9
Permits and EIL	0.0	234.3
Total Incremental Costs	81,212.0	15,513.8
Total Costs (including baseline costs for cooling pond)	81,212.0	16,318.6

Leachate/run-off from the existing gypsum stack as well as cooling water held in the existing cooling pond would be lime treated in the same manner as described in Engineering Alternatives 1 and 2.

Effluent from the neutralization mixing basin, consisting of cooling water at pH 3.5 and calcium fluoride (CaF_2) sludge generated by the lime treatment, would be routed first to an unlined sludge disposal surface impoundment, where as much settling of the sludge as possible would be allowed to occur. Decanted water of pH 3.5 would flow from this impoundment to the existing cooling pond for cooling.[25] The existing cooling pond would have to be expanded by an additional 50 acres to make up for the surge capacity lost from replacement of the existing gypsum stack with a new, lined unit.[26]

As in Engineering Alternative 3, the facility would construct an environmentally protective, lined gypsum stack for disposition of its untreated gypsum slurry. The gypsum slurry in its current form (i.e., untreated, no additional filtration) would be placed in the new stack. Water in the settling pond on top of the stack (e.g., transport water, rainfall) would be collected via decantation, rainfall run-off would be collected via lined ditches, and leachate would be collected via leachate collection systems built under the stack and over the stack liners. These combined waters would be captured in a new 50-acre stack leachate/run-off pond and returned to the gypsum filter to recover entrained P_2O_5 product. Because the leachate will generally be corrosive over the 15 years that treatment of the existing leachate occurs, lined impoundments would be required.

Because Subtitle C regulations prohibit the use of disposal waste piles and, hence, phosphogypsum stacks, this engineering alternative could not be used to comply with Subtitle C requirements. Differing scenarios exist for meeting potential Subtitle C-Minus and Subtitle D-Plus requirements; details concerning the stacks and the lined stack leachate/run-off pond are described in Engineering Alternative 3. Permitting and EIL costs would be incurred whenever stacks are used; details about these costs are presented in Engineering Alternative 1.

<u>Capital and Annualized Compliance Costs</u>

Results of the cost impact analysis for Engineering Alternative 4 are presented in Exhibit 6. The incremental annualized compliance cost (ACC) is expected to be $29.2 million if a Subtitle C-Minus stack is assumed, and $22.6

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[25] EPA assumes in this analysis that sufficient settling of the CaF_2 sludge would occur in the surface impoundment and that decanted cooling water of pH 3.5 could then flow to the existing cooling pond for cooling. EPA acknowledges, however, that the characteristics of CaF_2 sludge, which is 70 to 80 percent water and has a very fine-grained consistency, may limit the degree to which settling may occur in the impoundment.

[26] EPA assumes here that in order to control facility-wide water balance, a facility operator would not wish to co-mingle the treated cooling water with untreated slurry in the lined gypsum stack.

EXHIBIT 6

INCREMENTAL COSTS FOR ENGINEERING ALTERNATIVE 4 (C-) (Construct Lined (Subtitle C-Minus) Stack and Treat Cooling Water) (in $ thousands)		
UNIT	**CAPITAL**	**ACC**
Lime Treatment	2,986.9	6,234.9
CaF_2 Sludge Disposal Impoundment	2,126.1	699.1
Stack Leachate/Runoff Pond	11,042.8	2,385.9
Cooling Pond Expansion - Additional 50 Acres	647.7	186.2
Acid Losses	0.0	4,038.1
Lined Gypsum Stack	83,985.2	15,360.0
Permits and EIL	0.0	337.0
Total Incremental Costs	100,788.7	29,241.2
Total Costs (incl. baseline costs for cooling pond)	100,788.7	30,269.2

INCREMENTAL COSTS FOR ENGINEERING ALTERNATIVE 4 (D+) (Construct Lined (Subtitle D-Plus) Stack and Treat Cooling Water) (in $ thousands)		
UNIT	**CAPITAL**	**ACC**
Lime Treatment	2,986.9	6,234.9
CaF_2 sludge Disposal Impoundment	2,126.1	699.1
Stack Leachate/Runoff Pond	11,042.8	2,385.9
Cooling Pond Expansion - Additional 50 Acres	647.7	186.2
Acid Losses	0.0	4,038.1
Lined Gypsum Stack	50,072.2	8,845.0
Permits and EIL	0.0	234.3
Total Incremental Costs	66,875.7	22,623.5
Total Costs (incl. baseline costs for cooling pond)	66,875.7	23,652.5

million if a Subtitle D-Plus stack is assumed. When costs for the baseline cooling pond that will continue to be operated are included, the total annual management cost is $30.3 million for a Subtitle C-Minus scenario and $23.7 million for a Subtitle D-Plus scenario. The incremental capital required in year one to implement this alternative is estimated to be $100.8 and $66.9 million under Subtitle C-Minus and D-Plus, respectively. Approximately $1.5 million in capital is already invested in the baseline cooling pond that would continue to be operated.

As seen in Exhibit 6, the ACC for this scenario is composed primarily of the gypsum stack (53 percent of total incremental ACC for Subtitle C-Minus and 39 percent under Subtitle D-Plus scenarios). ACC costs for treating the cooling water account for $6.2 million of the total, or 21 and 28 percent of the total for Subtitle C-Minus and D-Plus compliance, respectively.

Engineering Alternative 5: Construct lined stack and recover FSA/treat cooling water[27]

<u>Description</u>

Under Engineering Alternative 5, a facility would manage its gypsum slurry and its cooling water completely separately (BFD 5). Fluosilicic acid (FSA) would be recovered in a double-stage process from vapors derived from both the phosphoric acid reaction and evaporation operations (provided that an adequate market for recovered FSA exists -- see Engineering Alternative 2). Once FSA is removed, the cooling and condensed waters would be lime treated in a neutralization mixing basin to remove the remaining fluorides and to raise the pH to approximately 3.5. In addition to treating the low fluoride wastewater resulting from the recovery operations, both leachate/run-off from the existing gypsum stack as well as cooling water held in the existing cooling pond would be lime treated in the same manner as described in Engineering Alternatives 1, 2, and 4.

The effluent from the neutralization mixing basin, consisting of cooling water at a pH of approximately 3.5 and CaF_2 solids from the lime treatment, would be routed to the unlined sludge disposal surface impoundment described in Engineering Alternative 2, then to the existing cooling pond for cooling. As in Engineering Alternative 4, the existing cooling pond would have to be expanded by an additional 50 acres to make up for the surge capacity lost from replacement of the existing gypsum stack with a new, lined stack.

The facility would construct an environmentally protective lined gypsum stack for disposition of its untreated gypsum slurry. The gypsum slurry in its current form (i.e., untreated, no additional filtration) would be placed in the new stack; leachate and run-off from this new unit would be collected

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[27] Engineering Alternative 5 proposes to construct a new, lined gypsum stack, lime treat the existing cooling pond and gypsum stack leachate/run-off and recover fluosilicic acid (FSA) from the cooling water with supplemental lime treatment.

in a 50-acre lined collection pond as described in detail in Engineering Alternative 3. Leachate from the existing pond would be collected in ditches around the old unit and the waters routed to the lime treatment operation as discussed above.

Because Subtitle C regulations prohibit the use of disposal waste piles and, hence, phosphogypsum stacks, this engineering alternative could not be used to comply with Subtitle C requirements. Differing scenarios exist for meeting potential Subtitle C-Minus and Subtitle D-Plus requirements; details concerning the stacks and the lined stack leachate/run-off pond are described in Engineering Alternative 3. Permitting and EIL costs would be incurred whenever stacks are used; details about these costs are presented in Engineering Alternative 1.

Capital and Annualized Compliance Costs

Results of the cost impact analysis for Engineering Alternative 5 are presented in Exhibit 7. If the assumption is made that no credit will be realized from the sale of fluosilicic acid, the incremental annualized compliance cost (ACC) is expected to be $27.0 million if a Subtitle C-Minus stack is assumed, and $20.4 million if a Subtitle D-Plus stack is assumed. The total ACC including baseline costs under this scenario are $28.0 million and $21.4 million under Subtitles C-Minus and D-Plus, respectively. However, if credit from the sale of FSA is recognized at the rate of $100/ton, the incremental annualized compliance cost is expected to be $23.9 million if a Subtitle C-Minus stack is assumed, and $17.3 million if a Subtitle D-Plus stack is assumed.. In this case, the total ACC including baseline costs are $24.9 and $18.3 for Subtitles D-Minus and D-Plus, respectively. The incremental capital required in year one to install this alternative is estimated to be $106.7 and $72.8 million under Subtitle C-Minus and D-Plus, respectively. Approximately $1.5 million in capital is already invested in the baseline cooling pond that would continue to be operated.

As seen in Exhibit 7, the ACC for this scenario is accounted for primarily by the gypsum stack (57 percent of total incremental ACC for Subtitle C-Minus and 43 percent under D-Plus). A large portion of the ACC is attributable to the acid losses of over $4 million annually (expected primarily from scaling due to the higher pH and the calcium load in the treated water). The remaining ACC for this scenario is primarily from the lime treatment, FSA recovery, and the lined stack leachate/run-off pond (liners needed because the transport water and gypsum are not treated before release to the stack/pond system). These three items are expected to cost approximately $2.2 million to $2.4 million each. Double-stage FSA recovery is the most cost-effective option for this engineering alternative, assuming that FSA markets remain stable and a price of $100 per ton can be maintained. This assumption results in a credit of over $3.0 million, which offsets a significant portion of the actual costs. Should market demand fall, and the acid be priced as low as $35 dollars per ton, the single-stage FSA recovery option (see Appendix B-2a) becomes the least cost alternative. Assuming, however, that a Subtitle C-Minus or D-Plus impoundment could be used to manage corrosive cooling waters (see Alternative 3), this $35 per ton FSA price

EXHIBIT 7

INCREMENTAL COSTS FOR ENGINEERING ALTERNATIVE 5 (C-) (Construct Lined (Subtitle C-Minus) Stack and Recover FSA/Treat Cooling Water) (in $ thousands)		
UNIT	CAPITAL	ACC
Lime Treatment	2,986.9	2,189.9
Double-Stage FSA Recovery*	7,872.0	2,208.0
CaF_2 Sludge Disposal Impoundment	199.8	276.4
Stack Leachate/Runoff Pond	11,042.8	2385.9
Cooling Pond Expansion - Additional 50 Acres	647.7	186.2
Lined Gypsum Stack	83,985.2	15,360.0
Acid Losses	0.0	4,038.1
Permits and EIL	0.0	337.0
Total Incremental Costs	106,734.4	26,981.5
Total Costs (including baseline costs)	106,734.4	28,010.5

FSA Sales Credit (at $100/ton of FSA)	0.0	(3,066.0)
Total Incremental Costs	106,734.4	23,915.5
Total Costs (including baseline costs)	106,734.4	24,944.5

EXHIBIT 7 (continued)

INCREMENTAL COSTS FOR ENGINEERING ALTERNATIVE 5 (D+)
(Construct Lined (Subtitle D-Plus) Stack and Recover FSA/Treat Cooling Water)
(in $ thousands)

UNIT	CAPITAL	ACC
Lime Treatment	2,986.9	2,189.9
Double-Stage FSA Recovery*	7,872.0	2,208.0
CaF_2 Sludge Disposal Impoundment	199.8	276.4
Stack Leachate/Runoff Pond	11,042.8	2,385.9
Cooling Pond Expansion - Additional 50 Acres	647.7	186.2
Lined Gypsum Stack	50,072.2	8,845.0
Acid Losses	0.0	4,038.1
Permits and EIL	0.0	234.3
Total Incremental Costs	72,821.4	20,363.8
Total Costs (including baseline costs)	72,821.4	21,392.8

FSA Sales Credit (at $100/ton of FSA)	0.0	(3,066.0)
Total Incremental Costs	72,821.4	17,297.8
Total Costs (including baseline costs)	72,821.4	18,326.8

* The decision to use double\stage recovery is based on the assumption that the FSA sales price is $100/ton.

threshold would never be reached as, below $90 a ton for FSA, the most cost effective alternative would be management in a lined impoundment.

Engineering Alternative 6: Treat slurry and construct lined cooling pond[28]

Description

Engineering Alternative 6 would treat the gypsum slurry with quicklime to a pH of approximately 3.5 in the gypsum tank (BFD 6). The lime slurry used to treat the gypsum slurry would be prepared in a lime receiving and slaking unit; treatment would take place in the existing gypsum tank. On implementation of the alternative, leachate/run-off from the existing gypsum stack would be lime treated in the same manner as described in Engineering Alternatives 1, 2, 4, and 5, that is, in conjunction with the gypsum slurry. Engineering Alternative 6 would also incorporate the additional filter area described in Engineering Alternative 1 to lower the lime demand for treating the gypsum slurry and the existing leachate/run-off.

Engineering Alternative 6 would, in lieu of treating the cooling water, manage the water in a newly constructed, composite-lined 150-acre cooling pond meeting the requirements of RCRA Subtitle C-Minus/D-Plus (BFD 6). The cooling pond required for Engineering Alternative 6 features a three-foot thick clay base overlain with a synthetic liner. The pond is 50 acres larger than the pond specified for Alternative 3 because the 50-acre surge capacity reserved on top the gypsum stack for overflow of the cooling pond during storm events could not be used to store the untreated cooling water, since the gypsum slurry would be treated to pH 3.5.

With the activation of the alternative, the cooling water in its current form (i.e., untreated) would be placed in the lined cooling pond. Water in the existing pond would not be treated, but would be pumped either into the plant as the primary feed for cooling requirements, or into the new lined cooling pond for storage before reuse. Once the existing pond has been drawn down, it would no longer be used for corrosive cooling water. The new cooling water system, with a lined cooling pond, would conceptually be a "closed-loop" system, with water coming to the pond and being recycled from the pond to the plant.

Treated gypsum slurry (and some portion of the treated existing stack leachate/run-off) would be pumped to the existing gypsum stack; an additional 50 acres would be required at the top of the stack for this alternative, with the cost of expansion carried by the existing unit (with no incremental cost).

Leachate/run-off from the gypsum stack would be captured in a new 50-acre stack leachate/run-off pond and returned to the gypsum filter to recover entrained P_2O_5 product. Engineering Alternative 6 (C-Minus/D-Plus)

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[28] Engineering Alternative 6 proposes to construct a new, lined cooling pond and lime treat the gypsum slurry and leachate/run-off from the existing gypsum stack.

would require a Subtitle C-Minus/D-Plus impoundment. These impoundments would require operating permits and environmental impairment liability (EIL) insurance.

For both the cooling pond and the stack leachate/run-off pond, no leachate collection/detection systems are employed; groundwater monitoring is, however, required for each pond to detect any liner failure.

Capital and Annualized Compliance Costs

Results of the cost impact analysis for Engineering Alternative 6 are presented in Exhibit 8. The incremental annualized compliance cost (ACC) is expected to be $9.6 million. When costs for the baseline gypsum stack, which would continue to operate and receive treated slurry, are included, the total annualized management cost is $10.9 million. The incremental capital required in year one to implement this alternative is estimated to be $43.3 million. Approximately $1.5 million in capital is already invested in the baseline cooling pond that would continue to be operated.

As seen in Exhibit 8, the ACC for this scenario is primarily related to the cooling pond, which accounts for 54 percent of the total incremental ACC. Treating the slurry and constructing and operating the stack leachate/run-off pond account for the majority of the remaining costs.

Engineering Alternative 7: Treat slurry and recover FSA/closed-loop system[29]

Description

As in Engineering Alternatives 1, 2, and 6, Engineering Alternative 7 would treat the gypsum slurry with quicklime to a pH of approximately 3.5 in the gypsum tank (BFD 7). The lime slurry used to treat the gypsum slurry would be prepared in a lime receiving and slaking unit; treatment would take place in the existing gypsum tank. On implementation of Engineering Alternative 7, leachate/run-off from the existing gypsum stack would be lime treated in the same manner as described in Engineering Alternatives 1, 2, 4, 5, and 6, that is, in conjunction with the gypsum slurry. Engineering Alternative 7 would incorporate the additional filter area described in Engineering Alternative 1 to lower the lime demand for treating the gypsum slurry and the existing leachate/run-off.

As in Engineering Alternatives 2 and 5, fluosilicic acid (FSA) would be recovered in either a single- or a double-stage process from vapors derived from both the phosphoric acid reaction and evaporation operations. As discussed below, EPA has estimated that if an adequate market for recovered

[29] Engineering Alternative 7 proposes to lime treat the gypsum slurry and stack leachate/run-off, manage cooling water in a closed loop system, and deplete the existing cooling pond through recycle to the process.

EXHIBIT 8

INCREMENTAL COSTS FOR ENGINEERING ALTERNATIVE 6 (C-/D+)
(Treat Slurry and Construct Lined (C-/D+) Cooling Pond)
(in $ thousands)

UNIT	CAPITAL	ACC
Lime Treatment	1,245.2	2,578.7
Additional Filtration	2,151.8	(917.8)
150-Acre Cooling Pond	28,906.0	5,185.2
Stack Leachate/Runoff Pond	11,042.8	2,385.9
Permits and EIL	0.0	337.0
Total Incremental Costs	43,345.8	9,569.0
Total Costs (including baseline costs)	43,345.8	10,936.5

FSA exists and remains stable, single-stage FSA recovery would be the most cost effective FSA recovery method for Engineering Alternative 7.

For Engineering Alternative 7, defluorinated vapors condensed following the recovery stage, instead of being lime treated to pH 3.5 and stored in a pond for cooling, would be passed through a closed loop heat exchanger system to effect cooling (as described in Section 2.ii.4 and shown in BFD 7). Non-contact cooling water that captures the heat of the defluorinated cooling and condensed wastewaters would be passed to a cooling tower, where the heat load would be liberated to the atmosphere through the evaporation of one percent of the total flow to the cooling tower. The majority (99 percent) of the cooling water from the tower would be returned to the water coolers where the heat load of the condensed, defluorinated waters is exchanged. The cooled wastewaters, which would still be at pH of less than 2, would be returned to the barometric condensers, the gypsum filter, and to the reactor as slurry water. Thus, because no water is returned to the existing cooling pond, the need for a cooling pond is eliminated.

The existing cooling pond, instead of being treated within the first year of implementation of the alternative, would be drawn down by recycle to the filter, as described below.

If single-stage FSA recovery were utilized, approximately 35 gpm of contaminated water from the water coolers could be added to the ball mill (see stream number 1 in BFD 7) before the fluorine content of these waters would exceed the fluorine limit of the mill (potentially corroding the balls) (stream numbers 29 and 30 in BFD 7).

If double-stage FSA recovery were utilized, the total flow of 200 gpm of water to the ball mill could be supplied by the contaminated waters from the water coolers in the heat exchanger system because their fluorine content would not exceed the fluorine limit of the mill (i.e., enough fluorine would be removed in double-stage recovery). Barometric condenser streams returned to the filter would be supplemented by a stream from the existing cooling water pond; this would allow drawdown of the pond in approximately three years (at a rate of 235 gpm) if single-stage FSA recovery were utilized and in approximately two years (at a rate of 400 gpm) if double-stage FSA recovery were utilized. The pond would be emptied more rapidly in the presence of double-stage FSA recovery because more pond water would be needed since most of the barometric condenser return water would be sent to the ball mill. EPA has assumed that because the pond would be emptied and no water would be returned to it, the pond water would not require lime treatment and there would be no associated treatment cost.

As in Engineering Alternatives 1, 2, and 6, treated gypsum slurry (and some portion of the treated existing stack leachate/run-off) would be pumped to the existing gypsum stack; an additional 50 acres would also be required at the top of the stack for this alternative, with the cost of expansion carried by the existing unit (with no incremental cost).

Leachate/run-off from the gypsum stack would be captured in a new 50-acre stack leachate/run-off pond and returned to the gypsum filter to

recover entrained P_2O_5 product. Engineering Alternative 7 (Subtitle C) would require a stack leachate/run-off impoundment that meets the Subtitle C criteria outlined in Section 2.ii.5, while Engineering Alternative 7 (C-Minus/D-Plus) would require a Subtitle C-Minus/D-Plus impoundment. These impoundments would require operating permits and environmental impairment liability (EIL) insurance.

Capital and Annualized Compliance Costs

Results of the cost impact analysis for Engineering Alternative 7 are presented in Exhibit 9. If the assumption is made that no credit will exist from the sale of fluosilicic acid, then the incremental annualized compliance cost (ACC) for Engineering Alternative 7 if a Subtitle C stack leachate/run-off pond is required is expected to be $15.0 million; when costs for baseline operations that will continue to be operated are included, the total annualized management cost under this scenario is $16.2 million. If a Subtitle C-Minus/D-Plus stack leachate/run-off pond is assumed, then the incremental annualized compliance cost is expected to be $13.9 million; when the baseline costs are included, the total ACC is estimated to be $15.0 million. Assuming, alternatively, that credits of $100 per ton of fluosilicic acid will be available, the incremental annualized compliance costs would be $12.6 million and $11.4 million under the Subtitle C and C-Minus/D-Plus scenarios, respectively. The total annualized management costs under this scenario are estimated to be $13.7 million and $12.6 million under Subtitles C and C-Minus/D-Plus, respectively. The incremental capital required in year one to install this alternative under Subtitle C is estimated to be $38.7 million. Under Subtitle C-Minus/D-Plus, the incremental capital required in year one is estimated to be $32.5 million. Approximately $2.3 million in capital is already invested in the baseline gypsum stack that would continue to be operated.

As seen in Exhibit 9, the ACC for this scenario is driven relatively evenly by lime treatment ($2.2 million), FSA recovery ($1.1 million), the closed loop heat exchanger system ($3.8 million), and the acid losses ($4.0 million), which are expected primarily from scaling due to the higher pH and the calcium load in the treated water. Single-stage recovery is the most cost-effective option for this Engineering Alternative assuming that FSA markets remain stable and a price of $100 per ton can be maintained. This assumes a credit of over $2.4 million, which would offset a significant portion of the actual costs. Market prices for FSA would have to climb to $191 per ton before double-stage FSA recovery would become viable. Should, as is more likely, markets fall and the acid be priced below $90 per ton, and assuming that Subtitle C-Minus or D-Plus impoundments could be used to manage corrosive cooling waters, the most cost-effective alternative would not be treatment or FSA recovery, but management in a lined impoundment.

EXHIBIT 9

INCREMENTAL COSTS FOR ENGINEERING ALTERNATIVE 7 (C)
(Treat Slurry and Recover FSA/Closed Loop System)
(in $ thousands)

UNIT	CAPITAL	ACC
Lime Treatment	1,245.2	2,232.7
Additional Filtration	2,151.8	(917.8)
Single-Stage FSA Recovery*	3,936.0	1,104.0
Closed-Loop Cooling System	11,854.0	3,789.7
Cooling Tower	2,243.0	956.6
Stack Leachate/Runoff Pond	17,286.3	3,509.4
Acid Losses	0.0	4,038.1
Permits and EIL	0.0	337.0
Total Incremental Costs	38,716.3	15,049.7
Total Costs (including baseline costs)	38,716.3	16,170.3

FSA Sales Credit (at $100/ton of FSA)	0.0	(2,489.3)
Total Incremental Costs	38,716.3	12,560.4
Total Costs (including baseline costs)	38,716.3	13,681.0

EXHIBIT 9 (continued)

INCREMENTAL COSTS FOR ENGINEERING ALTERNATIVE 7 (C-/D+)
(Treat Slurry and Recover FSA/Closed Loop System)
(in $ thousands)

UNIT	CAPITAL	ACC
Lime Treatment	1,245.2	2,232.7
Additional Filtration	2,151.8	(917.8)
Single-Stage FSA Recovery*	3,936.0	1,104.0
Closed-Loop Cooling System	11,854.0	3,789.7
Cooling Tower	2,243.0	956.6
Stack Leachate/Runoff Pond	11,042.8	2,385.9
Acid Losses	0.0	4,038.1
Permits and EIL	0.0	337.0
Total Incremental Costs	32,472.8	13,926.2
Total Costs (including baseline costs)	32,472.8	15,046.8

FSA Sales Credit (at $100/ton of FSA)	0.0	(2,489.3)
Total Incremental Costs	32,472.8	11,436.9
Total Costs (including baseline costs)	32,472.8	12,557.5

* The decision to use single-stage recovery is based on the assumption that the FSA sales price is $100/ton.

Comparison of Cost Results

A summary of the estimated annualized compliance costs of the seven engineering alternatives are presented in Exhibit 10. Also included in the summary table are the costs for the model plant using the costs model and assumptions developed for managing phosphogypsum and process wastewater in the RTC. Two tables are presented, the first presents the estimated ACC in millions of dollars per year while the second presents the annualized costs in terms of dollars per ton of P_2O_5 produced annually.

These estimated costs assume the need for waste management units (e.g., cooling water ponds, gypsum stacks) that are suitable in environments with the potential for high risk of damage to ground water. The costs also assume that baseline costs are the current typical management practice (i.e., in-situ clay liners with no leachate detection/collection). All costs are reported in 1989 dollars to correspond with the compliance cost estimates presented in the RTC.

As described above, EPA, in its analysis of waste management alternatives in the Report to Congress, considered the least-cost option in examining the costs of the alternatives from a compliance perspective. In this analysis, however, it is not clear to the Agency that the least-cost alternative will drive estimates of the total national cost of the regulatory options because the lowest cost alternative may not be the same for all phosphoric acid facilities.

4. SUMMARY OF FINDINGS

Based on the foregoing evaluation of the sources and sinks of contaminants in the phosphoric acid production process, analysis of pollution control technologies and waste management strategies, and operational and cost assessment of the selected engineering alternatives, EPA has developed the following general conclusions regarding potential alternatives for the management of phosphogypsum and process wastewater from phosphoric acid production.

Management of Phosphogypsum Slurry

<u>Installing an additional filtration unit and treating the resulting slurry with lime would be the most cost-effective method of managing corrosive gypsum slurry (i.e., phosphogypsum and process wastewater) from phosphoric acid production.</u> Installing additional filtration area would recover additional product acid and reduce both the quantity of acid that must be treated and the quantity of product that would be lost or wasted. This would enhance environmental protection efforts while potentially decreasing revenue lost to the plant. Regarding the management of gypsum slurry, EPA offers the following observations:

- The decision between the filter/treat and no-filter/treat options for treating gypsum slurry is driven by the amount of phosphoric acid recovered and the profit margin on the recovered acid.

EXHIBIT 10

MATRIX OF ESTIMATED ANNUAL COMPLIANCE COSTS (ACC) FOR ENGINEERING ALTERNATIVES (1-7) BY REGULATORY SCENARIO (in $ millions)

ENGINEERING ALTERNATIVE	INCREMENTAL COSTS			BASELINE COSTS
	Subtitle C	Subtitle C-Minus	Subtitle D-Plus	
1	14.8	13.7	13.7	1.6
2	12.5*	11.4*	11.4*	1.6
3	NA	22.1	15.5	1.6
4	NA	29.2	22.6	1.6
5	NA	27.0*	20.4*	1.6
6	NA	9.6	9.6	1.6
7	15.1*	13.9*	13.9*	1.6
RANGE	12.5 - 15.1	9.6 - 29.2	9.6 - 22.6	1.6
RTC	62.3	19.3	14.7	0.8

MATRIX OF ESTIMATED COST PER TON P_2O_5 OUTPUT FOR ENGINEERING ALTERNATIVES (1-7) BY REGULATORY SCENARIO

ENGINEERING ALTERNATIVE	INCREMENTAL COSTS			BASELINE COSTS
	Subtitle C	Subtitle C-Minus	Subtitle D-Plus	
1	44.05	40.70	40.70	4.74
2	35.12	33.97	33.97	4.74
3	NA	65.91	46.20	4.74
4	NA	87.08	67.37	4.74
5	NA	80.34	60.64	4.74
6	NA	27.47	27.47	4.74
7	46.53	43.18	43.18	4.74
RANGE	35.12 - 46.53	27.47 - 87.08	27.47 - 67.37	4.74
RTC	185.41	57.58	43.72	2.04

* The estimated annual compliance costs (ACC) presented assume that no credit is obtained from the sale of fluosilicic acid (FSA). If, however, FSA is sold at a market price of $100 per ton, the costs presented would decrease by approximately $3 million.

- Industry experts have indicated that nearly half of what is typically lost in the filter operation (4 percent of P_2O_5 input in EPA's model plant) could be recovered (2 percent or 20 tons per day for the model plant).

- If the net profit were to be greater than $187 per ton of recovered P_2O_5 then the filter/treat option would always be the least cost option. Given that additional production costs for phosphate rock, sulfuric acid, and electricity would not be incurred in producing the additional acid recovered, and that these three costs of production were, for a typical Florida phosphoric acid plant in 1989, valued at about 65 percent of the sales price, the lowest the profit margin could fall is $195 per ton recovered P_2O_5. Therefore, EPA expects that employing additional filtration prior to treating the gypsum slurry would always be the preferred management option in cases where lime neutralization of the gypsum slurry is required.

• Under full Subtitle C regulation, placement of corrosive slurry (or, if dry transport was under consideration, the filter cake with its contained non-recovered product acid) in a disposal waste pile and, therefore, a phosphogypsum stack, would not be permitted. Consequently, the only viable management alternatives under full Subtitle C regulation involve treatment; as discussed above, the most cost-effective option appears to be additional filtration followed by lime treatment of the gypsum slurry.

• Under Subtitle C-Minus or D-Plus regulations, disposal of corrosive slurry (or filter cake if dry transport was under consideration) in a phosphogypsum stack <u>would</u> presumably be permitted.

  - Lime treatment of the gypsum slurry, however, would be more cost-effective than disposal of the untreated slurry in lined stacks.

  - In the event that disposal in stacks would be preferred to treatment of the slurry, the following two considerations apply (assuming model plant conditions):

    (1) Subtitle D-Plus stacks represent a considerable cost savings over Subtitle C-Minus stacks; the savings, approximately $6.5 million annually, would be approximately 40 percent of the Subtitle C-Minus annualized cost.

    (2) A reassessment of the risk-to-ground water potential from high to moderate would allow facilities to realize considerable cost savings, with costs for a Subtitle C-Minus stack dropping to $11.6 million annually from $16 million annually. Subtitle D-Plus costs would also drop, though not as dramatically, from $9.4 million to $8.3 million annually

Management of Cooling Water

<u>FSA recovery would be the most cost-effective method of managing corrosive cooling waters from phosphoric acid production.</u> Using FSA recovery removes the bulk of the fluorine from cooling and condensed waters and recovers it in the form of a saleable product. The driving factor in this comparative analysis is the price (or management cost) per ton of FSA. EPA offers the following observations regarding this price (or management cost) per ton of FSA based upon this model plant analysis:

- Under Subtitle C regulations, where disposal of corrosive wastes in a lined impoundment would not be permitted, the following relationships hold:
  - If the average price per ton for FSA were to be greater than \$34.50, then double-stage FSA recovery would be most cost-effective;
  - If the average price per ton for FSA were to be between \$34.50 per ton and -\$99 per ton (i.e., average cost per ton to manage non-saleable FSA through lime treatment or tank storage and reuse in the plant were less than \$99 per ton), single-stage FSA recovery would be most cost-effective; and
  - If the average management cost per ton for FSA were to be greater than \$99 per ton, then no recovery would be used; lime treatment of all cooling water would be most cost-effective.
- Under Subtitle C-Minus and D-Plus regulations, where disposal of corrosive wastes in a lined impoundment <u>would</u> presumably be permitted, the following relationships hold:
  - If the average price per ton for FSA were to be greater than \$67.50, then double-stage FSA recovery would be most cost-effective;
  - If the average price per ton for FSA were to be less than \$67.50 per ton, then management of untreated cooling water in a composite-lined impoundment would be most cost-effective; and
  - Single-stage FSA recovery and treatment of all cooling water would never be a cost-effective option.
- Should management of untreated gypsum slurry in a lined gypsum stack (Alternatives 3, 4, or 5) be employed in place of treatment, then cost-effective management of cooling water would involve the following strategies:
  - If the average price of FSA were to be less than \$165.50 per ton, then the cooling water would be managed untreated in a composite-lined pond;

- If the average price of FSA were to be greater than $165.50 per ton, then double-stage FSA recovery would be most cost-effective;

- Single-stage FSA recovery and treatment of all cooling water would never be a cost-effective option.

• Under no circumstance would the closed loop cooling option be cost-effective, at least as presented in Engineering Alternative 7.

• Based on oral and written comments from the phosphoric acid industry and its representatives, EPA is uncertain about the availability of markets to absorb the additional supply of FSA that would be available if FSA recovery were implemented at several plants. EPA is equally uncertain of but nonetheless interested in the existence or development of alternative uses for recovered FSA, such as manufactured cryolite and uses in the hydrofluoric acid industry.

• Full-scale lime treatment of cooling and condensed waters is very expensive, relative to the other engineering alternatives, assuming that maintenance of equipment because of scaling due to additional calcium results in process down time and lost production.

Management of Stack Leachate

• EPA believes that all existing phosphogypsum stacks will continue to generate corrosive leachate for a considerable period, and that this phenomenon would need to be addressed under any regulatory scenario or engineering alternative.

  - EPA has assumed that management of corrosive stack leachate in a lined impoundment would be permitted, notwithstanding the recently promulgated Subtitle C land ban restrictions. The Agency believes that this type of active management may be a necessary response to potential environmental releases of a waste that is generated over a wide area rather than at a specific point, and solicits comment on this issue.

  - Over time, the corrosivity of the leachate from the existing stacks that would continue to be used to manage treated slurry would be expected to decrease as the historical acid accumulations are gradually leached out.

  - Acid in the lined stacks would continue to be corrosive over time but would be contained and collected in a leachate collection system.

Comparison to RTC Costs

• Total cost estimates are similar to those estimated for the Report to Congress. The following points of departure should, however, be noted.

- Total costs for Subtitle C cannot be compared between the two analyses for some Engineering Alternatives because no options exist in this report for managing untreated wastes in lined Subtitle C units, contrary to the analysis presented in the RTC (e.g., phosphogypsum was assumed to be managed in a Subtitle C disposal impoundment in the RTC, at an extremely high cost).

- Lime treatment costs in this report are higher than those reported in the RTC. Using the RTC model would have resulted in treatment costs of approximately $6 million annually for the model plant as compared to new estimates of approximately $9 million to $12 million.

APPENDICES

APPENDIX A - TRIP REPORTS

APPENDIX B - DETAILED COST TABLES

APPENDIX C - BLOCK FLOW DIAGRAMS

APPENDIX A - TRIP REPORTS

APPENDIX A1--TRIP REPORT

TEXASGULF/AURORA, NC,

TRIP REPORT

Texasgulf Phosphate Operations
Aurora, NC

August 22, 1990

Introduction

Section 8002(p) of the Resource Conservation and Recovery Act (RCRA) requires EPA to study the adverse effects on human health and the environment, if any, from the disposal and utilization of "solid waste from the extraction, beneficiation, and processing of ores and minerals, including phosphate rock and overburden from the mining of uranium ore," and submit a Report to Congress (RTC) on its findings.

On July 31, 1990, EPA published a Report to Congress on Special Wastes from Mineral Processing. Currently, EPA is preparing a regulatory determination that will establish whether or not regulation of any of the wastes covered by the RTC is warranted under subtitle C of RCRA. To assist in making this decision, the Agency is undertaking further collection and analysis of data on the generation and management of process wastewater and phosphogypsum from phosphoric acid operations. Collection of additional data is being accomplished in part through visits by EPA and Agency representatives to selected phosphoric acid facilities representing three major areas of phosphoric acid production.

A site visit to Texasgulf Phosphate operations was conducted on August 22, 1990; the facility is located in Aurora, North Carolina and is a primary mineral processor, producing the mineral processing products phosphoric acid, superphosphoric acid, and triple superphosphate, which the company produces from locally extracted and beneficiated phosphate rock. In addition the facility produces di- and mono-ammonium phosphate, purified acid and phosphoric acid based chemical products.

The purpose of the visit was primarily to gain a better understanding of the flow of water into and out of various sub-operations within the phosphoric acid facility. Pre-trip knowledge of process wastewater flows at phosphoric acid plants was confined to the total flow of water from the plant to the various waste management operations such as cooling ponds and gypsum stacks. This visit was the first step of an effort by the Agency to better understand what individual streams generated within the plant made up the total flow from the plant to the management units. While waste management operations were discussed and visited, gathering additional insight into their operations was of secondary importance. Following the trip, Texasgulf prepared for the Agency detailed flowcharts and charts describing the flow rates and contaminant loading; this material is attached.

The team that visited Texasgulf consisted of Bob Hall, Steve Hoffman, and Van Housman of EPA/Office of Solid Waste; Rich Pierce of ICF, Inc., and Larry Lai and Jack Faulk of SAIC. The primary Texasgulf personnel present during the visit were Jim Skillen, Guy Whitaker, and Bill Schimming; Thomas

Fegan was also present for a period. The visit took the form of a lengthy meeting during which processes and process wastewater flows were discussed followed by a brief tour of the phosphoric acid plant and associated operations.

Meeting Notes

The meeting was structured around a discussion of the integrated operations of the Texasgulf facility. The first topic was the beneficiation operations followed by the phosphoric acid plant and fertilizer operations.

Mining and Beneficiation--Texasgulf's first step in mining is to prestrip the mine using bucket wheel excavators to remove about 30-40 feet of overburden. Drag lines remove another 30-60 feet to get to the ore. The ore body is about 30 feet thick; the ore is removed with drag lines, slurried, and pumped to the beneficiation plant. A washer screens out large pieces, known as "rejects," which go to a waste pile for airdrying. Rejects are given to the State and public for use as road bed material. Texasgulf has done chemical analysis on the reject material and informed EPA during the visit that this information was available. Runoff from the rejects pile is presently ditched away and discharged; this practice will be discontinued by 1992 and the water routed to an on-site impoundment, referred to as the mill pond, that texasgulf uses to manage water for use in the mill.

The next step is to separate the clays during a feed preparation stage; the waste clay is sent through two thickener operations to remove water, which is discharged via NPDES. The clays, which were previously discharged directly to a slime pond, are currently sent to blend tanks to be mixed with phosphogypsum to create a material used to fill the mine cut. Texasgulf noted that this blending is possible because of the neutralization capacity of the North Carolina clays. The company noted that hopper car cleanouts (e.g., grain, corn) may be mixed with this clay/gypsum blend. The material from the blend tank is 60-70 percent water; this slurry is sent to an unlined holding lake, the reclaim lake, that is diked with sand from the flotation operation. The decant from the reclaim lake, which is pH 6-7, is currently discharged to a NPDES outfall. A new lake, the recycle lake, is under construction; it will be 200 acres and lined with a clay/gypsum blend liner. Decant from this lake will be used to slurry ore from the mine to the mill.

The phosphate feed goes next to a flotation operation. Texasgulf uses a two stage flotation. In the first stage, fatty acid flotation is used in which the sand sinks and the phosphate floats. The sands that are removed from the floatation unit may be used in diking or sent to reclamation areas either directly or via the blend tank if pipelines problems occur. The second flotation stage is amine flotation where the sand floats; this operations may not always be conducted. The phosphate concentrate is stored in a concentrate pile.

From this pile the concentrate may go one of three places: the dryer/grinder operation, the calcine operation, or straight to the phosphoric acid attack stage. The dryer is an oil-fired kiln used to prepare rock for

granulated triple superphosphate production; this unit has a wet scrubber to control particulate air emissions. The calciner is a coal-fired fluidized bed roaster operated at 1500 degrees and used to decompose carbonate, burn organic carbon, and cleave waters of hydration. High sulfur coal is used because the decomposition of carbonate (CaO_3) produces CO_2 and CaO which acts as a natural SO_2 scrubber. The temperature used is not high enough to drive off fluorine or magnesium. Calcined feed goes to make cleaner "green" phosphoric acid used for, amongst other products, purified acid. Feed that goes directly to the acid operation is used to make "black" acid.

Much of the discussion about the mining and beneficiation operations concerned the closed loop recycled water system under construction. This system is designed to minimize the use of once-through water. Beginning in 1992, depressurized water (from the mine) will be used to slurry rock to the beneficiation operations; this water will remain in the system. The majority of the water will be discharged without use, with the potential to use part of the stream as makeup to the operations when necessary. Of the 40,000 gpm expected to be pumped (assuming current pumping rate), 33,000 gpm will be discharged and 7,000 gpm consumed. In the future, only cooling tower blowdown and the depressurized water quantity will be discharged; no once-through cooling water will be discharged.

<u>Sulfuric Acid plants</u>--Molten sulfur is brought in by rail. Fresh water is used to make the acid but must be purified first in a lime softening and ion exchange operation. Currently, regeneration water from this water treatment system is discharged via an NPDES outfall; under the new water management plan this water will go to the neutralization plant (it has a pH of about 10). Currently this flow amounts to 80-100,000 gpd. There are five sulfuric acid manufacturing trains using double adsorption with V_2O_5 catalysts to produce 3.4 million tons annually of 95 percent acid. Flows from mist eliminators, spills, and tank inspections go to the new elementary neutralization unit.

<u>Phosphoric Acid Operations</u>--Calcined or wet uncalcined rock is reacted with sulfuric acid in one of four production "trains". According to Texasgulf, the key to the operation is to generate gypsum crystals that can be filtered. Tilting pan and belt filters are used; only gypsum from the belt filter can be sent directly to blend operation. The filtered acid is clarified to remove solids (which are returned to the filter operation), then concentrated to bring the 25-30 percent acid up to 50-55 percent acid.

Two types of gypsum are possible: dihydrate ($CaSO_4$-$2H_2O$) which forms at temperatures of about 160-170°F and concentrations of 20-30 percent P_2O_5, or hemihydrate ($CaSO_4\cdot1/2\ H_2O$)which forms under higher temperatures (200-210°F) and higher (40-45 percent) concentrations of P_2O_5. Both type operations bring magnesium and fluoride into solution but the hemihydrate process liberates more fluoride which volatilizes and is routed to the flash cooler/condenser or the fume scrubber operations where the fluorides are captured in condenser cooling water or scrubber water. Texasgulf indicated that it appears that uranium in the beneficiated phosphate rock stays with the acid rather than

...th the gypsum. They also stated that uranium content in North Carolina ore .. only 30-40 percent of the levels in Florida ore.

The gypsum at Texasgulf is located in six stacks, only one of which is active. Gypsum is being recovered from one idle stack for sale as land plaster (fertilizer) for peanut crops; another stack is being reclaimed to the blend operation discussed above under clay management. The company plans to eventually operate only three stacks; one that is active, one that is drying, and one that is being reclaimed to the blend operation. [1]

The concentration operation is performed in evaporators that use shell and tube heat exchangers to transfer heat from steam to the acid. The water and fluorides that are vaporized in the evaporator are condensed in barometric condensers using contact water (pond water); this condenser cooling water is routed back to cooling pond #1. The resulting acid may be sold as merchant grade or further processed on site.

Two of the 16 evaporation units used to concentrate acid from 28 to 54 percent are equipped with fluosilicic acid recovery units. SiF_4 and HF from the evaporator are reacted to form H_2SiF_6 (Fluosilicic acid), which is cleaned and sold for water fluoridation. The fluoride removed from the phosphoric acid by the other evaporators goes out with the scrubber and concentrator waters to the ponds.

The cooling ponds receive and store waters for return to the operation. This pond water is returned to the plant to be used to cool and wash (filter operation). Approximately 75,000 gpm of water is returned from the pond for use in the process. The pH of the pond water is approximately 1 to 1.5, due to accumulation of phosphoric, fluosilicic and sulfuric acid. The major source of phosphoric acid to the pond is return water from the gypsum stack; this is from the acid remaining in the filtered gypsum when it is slurried to the stack. Cooling pond #1 is not lined; natural clays underlie the unit. Slurry walls are planned to protect the river from process water seeping out of the pond. The net consumption of cooling water comes from pond #1; water is transferred in from pond #2 to maintain the water level in pond #1. Currently there are 21 monitoring wells in place around the pond.

<u>Water treatment plant</u>--This plant is used to neutralize acidic previously excluded mineral wastewaters that were hitherto sent to the cooling pond. This operation came on-line July 20, 1990. Major streams to the facility are from sulfuric acid plant and purified acid plant. The output from the system goes to the blend reclamation operation. The facilities consist of three concrete sumps and an agitator. The facility was built for $300,000.

<u>Granulated Fertilizer Operations</u>--Three plants produce granulated fertilizer; two produce DAP and one produces either MAP or GTSP. MAP or DAP

[1] Texasgulf personnel indicated that the State has informed Texasgulf that stacks are to be lined in the future (1992-1993).

generated by ammoniating phosphoric acid; the GTSP operation consists of reacting phosphate rock and phosphoric acid. All three plants generate a scrubber water; the GTSP produces a wastewater from evaporators in addition.

Cooling pond #2 is the destination and source of water for granulated product operations. The pH of the pond is 2.0 - 3.0. Fresh water to the two pond system is added to Pond #2 rather than #1; when water is needed for #1 it is bled from #2.

Superphosphoric Acid Operations--The concentrated (54 percent) acid is again heated in a shell and tube exchanger then routed to the evaporator to remove the remainder of the free water and concentrate the acid to 70 percent. This product can be sold or further filtered using a plate and frame press to get a purified product. Metallic phosphates are filtered out and routed to the granulated fertilizer feed.

Liquid fertilizer may be produced by first diluting the superphosphoric acid back to 54 percent then ammoniating the acid. Liquid fertilizer is a low volume specialized product produced only several months of the year.

Purified Acid Operations-- Green phosphoric acid is used as the feedstock to a solvent extraction (methyl isobutyl ketone) operation; phosphoric acid is extracted and impurities are left behind in a raffinate stream. This raffinate stream is routed to the granulated fertilizer operations for incorporation into that product and the solvent is stripped and recycled; the only waste is the cooling tower blowdown which goes to the neutralization plant. This operation came on line in January of 1990.

Blend Plant--Low sodium phosphoric acid is mixed with certain additives for special orders; there is reportedly no waste from this operation.

Tour Notes

- The neutralization facility used to neutralize previously excluded mineral processing waste was constructed in June, 1990. Construction of the surrounding superstructure was not yet complete; the tanks, pumps, and lime feed system were operational.

- The phosphoric acid plant visit included viewing of the gypsum collection and slurry sump, the tilting pan filter operation, the belt filter operations and the control room.

- The blend tank operation where phosphogypsum is blended with clay slimes to form a material that is returned to the mine areas was visited but is primarily a closed system with pipe feeds and returns so little could be observed.

- Cooling Pond #1 is where waters from the phosphoric acid operations are routed to cool before being returned to the plant. Three outfalls from the plant operations were pointed out and the gypsum stack return water

transported via a ditch was also noted. A long dike was observed to extend nearly to the far end of the pond, effectively making the pond a "U" shaped unit with the outfalls at one end and the return ducts at the other. It was explained that this design is used to maximize the distance that the water travels in the pond, thereby assuring maximum cooling.

- Cooling Pond #2 is where waters from superphosphoric acid and granulated fertilizer operations are managed. A dike system similar to the one used in the first cooling pond was observed. Corn and grain from hopper car cleanout were observed on the banks of the pond and in the shallows.

APPENDIX A2--TRIP REPORT

IMC/MULBERRY, FL

TRIP REPORT

IMC Fertilizer
Mulberry (New Wales), Florida

September 18, 1990

Introduction

EPA, along with its contractors, ICF Incorporated and SAIC, visited IMC Fertilizer in Mulberry, Florida on September 18, 1990. John Martinez, a chemical engineer with Badger Design and Constructors of Tampa, also attended the meeting to assist the Agency, its representatives, and IMC in a discussion of the plant's operations. Exhibit 1 presents a list of participants in the meeting.

EPA is currently preparing a regulatory determination that will establish whether or not regulation of any of the wastes covered by the July 31, 1990 Report to Congress on Special Wastes from Mineral Processing is warranted under Subtitle C of RCRA. The Agency, in order to better make this decision, is undertaking the task of further data collection and analysis of the generation and management of process wastewater and phosphogypsum from phosphoric acid operations. Collection of additional data is being accomplished in part through visits by EPA and Agency representatives to selected phosphoric acid facilities representing three major areas of phosphoric acid production. The primary goals of the visits were (1) to gain a better understanding of the flow of water into and out of various sub-operations within phosphoric acid facilities and (2) to continue to gather information in support of the Agency's upcoming regulatory determination on the RCRA status of process wastewater and phosphogysum. Pre-trip knowledge of process wastewater flows at phosphoric acid plants was confined to the total flow of water from the plant to the various waste management operations such as cooling ponds and gypsum stacks. This visit was part of an effort by the Agency to better understand what individual streams generated within the plant make up the total flow from the plant to the management units. While waste management operations were discussed and visited, gathering additional insight into their operations was of secondary importance.

The visit consisted of meeting in the morning during which processes and process wastewater flows were discussed; a tour of the phosphoric acid plant and associated operations during the afternoon; and a final meeting after the tour. The information gathered during those meetings and the tour are the topic of this report.

This trip report begins with an overview of IMC Fertilizer's plant production operations, including inputs to the process, the types of operations, and the products generated. Next, we describe highlights of the plant's waste management practices, focusing on sources of process wastewater, uses of returning pond water, other non-process wastewater sources and uses, and management of the plant's gypsum stack and associated water. The report concludes with flow charts and tables provided by IMC Fertilizer during the visit.

Overview of Plant Production Operations

IMC's New Wales Operations is the United States' largest producer of phosphoric acid and phosphate fertilizer ingredients. In 1988, the plant produced more than 1.4 million metric tons of P_2O_5 in the form of merchant grade (i.e., 54%) phosphoric acid, which was 15 percent of the total national production.

Exhibit 2 presents the types of operations, the number of units per operation, the material inputs to each operation, and the products generated by each operation. Exhibit 3 presents a cooling pond water balance for the facility, and Exhibit 4 presents a generalized process flow diagram. Attachment 1 includes a discussion provided by IMC of the quantities of cooling pond water used in each operation.[1] In the following sections, we describe each of the plant operations, with emphasis placed on process and non-process wastewater flows.

Wet Rock Grinding

IMC receives wet, beneficiated, 67 percent bone phosphate of lime (BPL) grade phosphate rock in the form of pebble and concentrate from eight IMC mines, including its Kingsford, Noralyn, Clear Springs, Phosphoria, and Four Corners mines in Florida. The rock, shipped to the plant by rail car and truck, is 10-12% water prior to processing. IMC consumes 15,000 tons per day (tpd) of this rock. IMC personnel report that all contaminants that eventually end up in the gypsum and process wastewaters are ultimately derived from the phosphate rock feed.

IMC utilizes two types of mills to grind the wet phosphate rock to a slurry of 67percent solids (see Exhibit 5). IMC grinds pebble feed in two parallel rod mills operated in an open circuit, and it grinds a blend of pebble and concentrate in two parallel ball mills operated in an closed circuit. The slurry is stored in tanks before it is sent to the phosphoric acid plants.

IMC utilizes about 1,500 gallons per minute (gpm) of water in the four grinding mills. As much as 500 gpm of this water is recycled from the process wastewater cooling pond; seeking to return as much acidity as possible from the cooling pond to the phosphoric acid attack tanks, IMC adds process wastewater with an average pH of 1.6 to the grinding mills almost to the point of corroding the rods and balls in the mills. The balance of the 1,500 gpm is made up by utility pond water, which consists of cooling tower and boiler blowdown from the sulfuric acid plant, wastewater streams from various coolers in the sulfuric acid plant, and ammoniated condensate streams from the diammonium phosphate plant. Utility pond water ranges between pH 3 and 11; as much as 100 gpm of cooling pond water is added to the utility pond when the utility waters are strongly alkaline.

[1] IMC refers to its process wastewater cooling pond as a gypsum pond, but the term "cooling pond" will be used in this report.

Sulfuric Acid Plants

IMC consumes up to 3,500 tpd of molten sulfur to produce 13,000 tpd of 98.5% sulfuric acid (H_2SO_4) in five plants (see Exhibit 6). Molten sulfur delivered by truck is stored in a concrete, steam-heated pit at 270°F, while molten sulfur delivered by rail is stored in heated, insulated tanks.

In the plants, the molten sulfur is burned with air at 2000°F, producing gaseous sulfur dioxide, nitrogen, and oxygen. This gas passes through a boiler where steam and a blowdown of pH 11-12 are generated. (IMC generates enough steam to power two of the phosphoric acid plants as well as a portion of the remainder of the facility.) The sulfur dioxide gas is then converted to gaseous sulfur trioxide by reactions with air in a converter in a series of four conversions in the presence of a vanadium pentoxide catalyst. (Spent catalysts are recycled to the catalyst manufacturer.) After three conversion steps that proceed from 60% to 85% to 95% conversion of sulfur dioxide to sulfur trioxide (at temperatures of 1140°F, 950°F, and 800°F, respectively), the gas is reacted with water and sulfuric acid in interpass and final absorption towers to produce 98.5% H_2SO_4. The final H_2SO_4 stream is cooled in a cooling tower, creating a blowdown of pH 7 that is sent to the utility pond. About 80,000 gpm of water circulates through the cooling towers.

IMC reports that it does not send any of the blowdown waters from the sulfuric acid plant to the process wastewater cooling pond, nor does it use any cooling pond water in the sulfuric acid plant.

Phosphoric Acid Plants

Attack and Filtration

IMC operates three wet process phosphoric acid trains that have a combined capacity of 4,500 tpd (1.75 million tons per year [tpy]) of 27% P_2O_5 (see Exhibit 7). Two of these trains are identical in construction; a third train of different construction was added in the mid-1980's. In each train, IMC digests 67% BPL phosphate rock with 96% H_2SO_4 in an attack tank.

Each train has two vacuum flash coolers that are used to cool the reacted solution. For each 2,000 tpd of P_2O_5 generated, IMC generates 200 gpm of vapor and entrained liquid in the flash coolers. Up to one-fourth of the fluoride introduced in the source phosphate rock is evolved in the vapor as SiF_4. The entrained liquid also contains some P_2O_5. IMC uses 25,000 gpm of water from the cooling pond to condense these vapors in barometric condensers. Upon condensation, the SiF_4 converts to fluosilicic acid (H_2SiF_6). The contacted cooling water, which now contains the condensed vapors as well as the entrained P_2O_5 and H_2SiF_6, is returned to the cooling pond at 135°F.

The reaction generates a slurry consisting of 27% P_2O_5 and gypsum ($CaSO_4 \cdot 2H_2O$), which are then separated with a Bird-Prayon tilting pan filter using vacuum filtration. IMC uses countercurrent washing (i.e., cross-flow filtration) on the filter to minimize particle accumulation at the filter surface and maintain a high filtration rate, thereby minimizing residual

losses of water soluble P_2O_5 to the gypsum cake. Two consecutive washings of the filter with 3,000 gpm of cooling pond water is the most economical and practical procedure. The filter is only large enough for two washings; wash water overflows when a third wash is attempted.

IMC loses 1-6% water soluble P_2O_5 (as diluted 27% H3PO4) to the gypsum slurry that is sent to the gypsum stack. There is also a loss of as much as 4% insoluble P_2O_5 from the attack tank to the gypsum stack. Thus, the plant recovers 90% or more of the P_2O_5 that is introduced to the process in the phosphate rock feed. IMC reported that it recovers about 50% of the P_2O_5 lost to the cooling pond through recycling process wastewater to the attack tanks. There is also a loss of 2% residual H_2SO_4 in the P_2O_5 product.

Opportunities to lower the 1-6% P_2O_5 lost to the gypsum from the filter include

- increasing the surface area of the filters (the filters are approximately 75 feet in diameter),
- increasing the number of filters, and/or
- increasing the size of the gypsum crystals formed in the attack tanks, thereby decreasing the pore space available in the gypsum matrix for water soluble P_2O_5.

The gypsum cake remaining on the three filters is slurried with a total of 16,000 gpm of cooling pond water and sluiced to the gypsum stack under gravity flow. The filtrant, which consists of 27% P_2O_5, 2% F as H_2SiF_6, 2.5% H_2SO_4, 2% SO_3, 1.5% Fe_2O_3, 1.1% Al_2O_3, and 0.6-0.9% MgO, is passed to the uranium recovery process and then to evaporation and clarification.

Uranium Recovery

IMC is under contract with the federal government until 1992 to extract uranium oxide from the 27% P_2O_5 filtrant that results from the attack phase. Phosphoric acid filtrant, also known as "brown acid", is cooled in heat exchangers from 180°F to 130°F using 3,000 gpm of non-contact cooling pond water that is returned to the pond. A bentonite flocculant is added to the acid in a clarifier to remove 200-400 tpd of gypsum solids that are removed to the gypsum stack. In the first step of the extraction process, the uranium in the brown acid is oxidized and then extracted from the acid with an organic solution known as DEPA-TOPO. The P_2O_5-containing brown acid is concentrated to 30% in this step and is sent to a storage tank before evaporation and clarification. Approximately 2,400 gpm of brown acid are treated in this step. The resulting uranium-rich organic solution is concentrated to reduce the volume of the solution and increase the percentage of uranium. The uranium is then re-extracted or stripped from the solution, again with DEPA-TOPO, and transferred to an ammonium carbonate solution. IMC precipitates "yellowcake" (uranium oxide, U_3O_8) from this solution using

hydrogen peroxide at an on-site facility. IMC produces 550 tpy of yellowcake at this facility.

In addition to the 3,000 gpm of process wastewater used for indirect cooling of the brown acid, 500 gpm of process wastewater is used in weekly washings to remove scale from pipelines and to scrub vapors from equipment using two fume scrubbers. Scale consists of gypsum, iron ammonium phosphate, iron phosphate, and potassium and sodium fluosilicic solids. These solids are also sent to the gypsum stack.

Evaporation

The goal of the evaporation step is to boil off water in the phosphoric acid filtrant to increase the percentage of P_2O_5 in the solution. IMC uses 12 evaporators to concentrate the 30% P_2O_5 solution to 40%, 48%, and finally 54% P_2O_5. An intermediate clarification step after the first evaporation prepares the 40% P_2O_5 solution for the granular triple superphosphate (GTSP) process.

The vapor produced in each evaporation step is condensed in barometric condensers with 5,000 gpm of cooling pond water per condenser, with a total flow of 60,000 gpm for all evaporators. The resulting process wastewater is returned to the cooling pond at 110-140°F. IMC reported that despite an entrainment separator on the 40% evaporator that recovers P_2O_5 from the vapor generated in the evaporator, it still loses approximately 7 tpd of P_2O_5 in the vapor. As in the case of the flash coolers in the attack process, the evaporation step liberates one-fourth of the fluoride introduced in the source rock. This fluoride is converted from SiF_4 in the vapor to H_2SiF_6 in the process wastewater that is discharge to the cooling pond. IMC does not recover H_2SiF_6 because the quantity that would be recovered would exceed perceived market demand.

Clarification

In addition to the intermediate clarification described above, IMC clarifies approximately 600 tpd of its 54% P_2O_5 to produce "merchant grade" phosphoric acid for sale. The remaining 3,300 tpd are utilized in the production of granular monoammonium and diammonium phosphate (MAP and DAP, respectively), GTSP, animal feed ingredients (AFI), and Multifos, a low-fluorine animal feed supplement.

<u>Monoammonium Phosphate Plant</u>

IMC reacts ammonia in a prill spray tower with the impure phosphoric acid sludge that results from the clarification of 54% P_2O_5 to produce 900 tpd of non-granular monoammonium phosphate (MAP) (Exhibit 8). MAP is a 10-50-0 fertilizer that is used in bulk blends, suspension fertilizers, and granulation plants. In the process, the MAP is directed to a rotary cooler that is vented to a Venturi scrubber. IMC uses 25 gpm of cooling pond water to scrub vapors in the scrubbers and returns the water, which contains recovered P_2O_5 and H_2SO_4, to the cooling pond. This process is performed in the No. 1 DAP plant.

Diammonium Phosphate Plants

IMC operates two diammonium phosphate plants that are nearly the same in operation. IMC produces granular DAP, an 18-46-0 fertilizer, by reacting 54% P_2O_5 with ammonia and granulating the resulting slurry to a spherical form Exhibit 9). In the No. 1 DAP plant, IMC uses 4,000 gpm of cooling pond water to scrub vapors in one fume scrubber. Up to 100 gpm of cooling pond water are also added to the scrubber and then pumped to the DAP reactor to recover P_2O_5 and H_2SO_4. Both of these streams are returned to the cooling pond. IMC produces 2,400 tpd of DAP in the No. 1 DAP plant, and it also periodically manufactures granular MAP in the No. 1 DAP plant.

The No. 2 DAP plant is composed of two units (reactors) that together produce 4,800 tpd of DAP. IMC uses 14,000 gpm of cooling pond water to scrub vapors in four fume scrubbers and up to 200 gpm to recover P_2O_5 and H_2SO_4 from the reactor. Both streams are returned to the cooling pond. Up to 100 gpm is used to neutralize an ammoniated condensate stream that is sent to the utility pond.

Granular Triple Superphosphate Plant

IMC produces 1,200 tpd of granular triple superphosphate (GTSP), a 0-46-0 fertilizer, by reacting 40% P_2O_5 with finely ground 73% BPL phosphate rock (Exhibit 10). The resulting slurry is granulated to a spherical product. IMC uses 4,000 gpm of cooling pond water to scrub vapors from the GTSP process using four fume scrubbers and up to 50 gpm in the reactor that recovers P_2O_5 and H_2SO_4. Both streams are returned to the cooling pond.

Defluorination

In order to produce low-fluorine animal feed supplements, IMC defluorinates 600 tpd of 54% P_2O_5 in a batch tank using silica to remove fluoride. IMC uses 16,000 gpm of cooling pond water to condense vapors, which contain SiF_4 and P_2O_5, from two evaporators using barometric condensers. Upon condensing, the SiF_4 is converted to H_2SiF_6. IMC sends 6,000 gpm of the flow to the Multifos plant; the remainder is returned to the cooling pond.

Animal Feed Plant

IMC reacts ammonia with defluorinated P_2O_5 to produce the defluorinated ammonium phosphates Monofos and Duofos and reacts limestone with defluorinated P_2O_5 to produce the defluorinated calcium phosphates Dynafos and Biofos (Exhibit 11). IMC produces up to 2,500 tpd of these products. IMC uses 6,000 gpm to scrub vapors from the AFI equipment in four fume scrubbers. The flow is returned to the cooling pond.

Multifos Plant

IMC reacts non-defluorinated 54% P_2O_5, soda ash, and 75% BPL phosphate rock in a high temperature calcining kiln to produce 300 tpd of tricalcium phosphate, also known as Multifos, another low fluorine animal feed supplement

...ibit 12). IMC uses 1,000 gpm of cooling pond water and 6,000 gpm of ...rn water from the defluorination scrubbers to scrub vapors from the M...ifos equipment in three fume scrubbers. Up to 50 gpm of cooling pond water are also added to the acid batch tanks to recover P_2O_5 and H_2SO_4. These streams are returned to the cooling pond.

Highlights of Waste Management Practices

IMC's waste management operations consist of a 430-acre gypsum stack bordered on the east and south by a 280-acre cooling water pond. Process wastewater introduced to the stack in the gypsum slurry as well as direct rainfall that infiltrates the stack collect in an unlined rim ditch that surrounds the stack and flows to the cooling pond. The major sources of process wastewater to the cooling pond are

- condenser/cooling water from the flash coolers and evaporators,
- filtrate water from the gypsum stack that consists of both cooling pond water that was used to slurry gypsum to the stack and precipitation on the stack,
- filter losses, pump leaks, and spillage within the plant that is conveyed through drains to the pond,
- storm-water runoff from the plant, and
- direct precipitation.

A utility pond of approximately 50 acres is located between the plant and the gypsum stack and holds cooling tower and boiler blowdown from the sulfuric acid plant, wastewater streams from various coolers in the sulfuric acid plant, and ammoniated condensate streams from the diammonium phosphate plant. IMC reported that the pH of the cooling pond averages around 1.6 while the pH of the utility pond ranges from 3 to 11. IMC adds cooling pond water to the utility pond when it is strongly alkaline due to the SAP cooling tower blowdown and the DAP condensate streams.

IMC plans to add a new 400-acre gypsum field that will be lined with polyethylene and will have a leachate collection system. IMC personnel stated that the Florida Department of Environmental Regulation is also requiring IMC to surround the plant with a slurry wall keyed to the limestone bedrock.

EXHIBIT 1

List of Attendees -- IMC Fertilizer, September 18, 1990

	Organization	Phone Number
Joe Baretincic	IMC Fertilizer	(813) 428-2531
John Bradford	IMC Fertilizer	(813) 428-2531
Jerry Girardin	IMC Fertilizer	(813) 428-2531
Don Hirsch	IMC Fertilizer	(813) 428-2531
Craig Pflaum	IMC Fertilizer	(813) 428-2531
Van Houseman	US EPA/OSW	(202) 475-7241
Larry Huffman	ICF Incorporated	(703) 934-3382
Peter Soyka	ICF Incorporated	(703) 934-3619
Larry Lai	SAIC	(703) 734-3195
John Martinez	Badger Design and Constructors, Inc.	(813) 289-1991

EXHIBIT 2
Operations, Inputs, and Outputs/Products at IMC Fertilizer

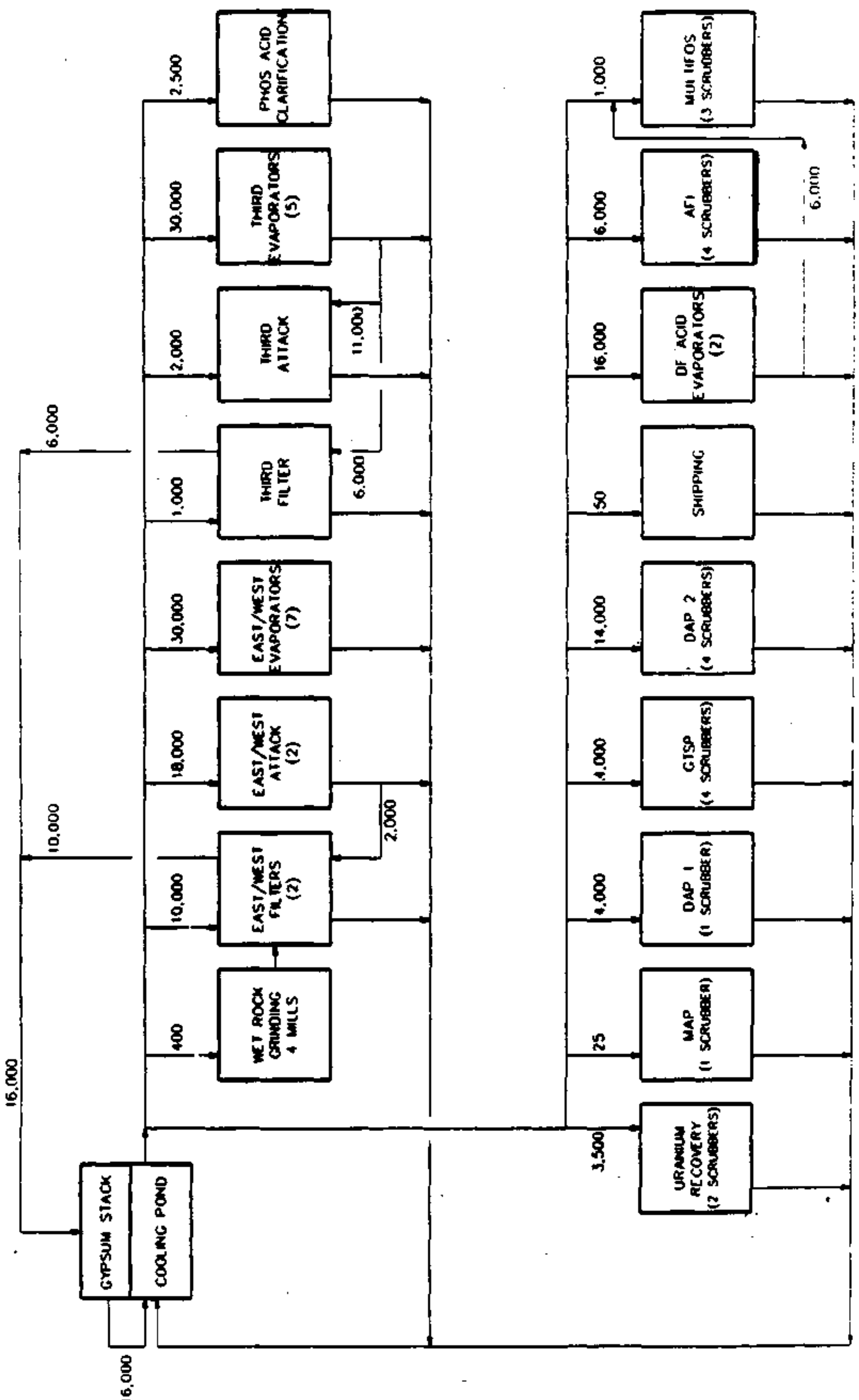
Operation	Number of Units	Inputs	Outputs/Products
Wet Rock Grinding	2 trains, each with a ball mill and a rod mill	15,000 tpd 67% BPL; 500 gpm PWW; 1,000 gpm utility water	Rock slurry to phosphoric acid attack tanks
Sulfuric Acid Production	5	3,500 tpd molten sulfur	13,000 tpd 100% H_2SO_4
Phosphoric Acid Production	3 trains	Phosphate rock slurry; 96% H_2SO_4; 93,500 gpm PWW	600 tpd 54% P_2O_5 for sale (merchant grade); 3,600 tpd P_2O_5 for input to other operations; 21,000 tpd gypsum; 93,500 gpm PWW
Uranium Recovery	1	27% P_2O_5; 3,500 gpm PWW	1.5 tpd yellowcake; 27% P_2O_5; 3,500 gpm PWW
Diammonium Phosphate Production (one plant also produces Monoammonium Phosphate)	3	54% P_2O_5; Ammonia; 18,000 gpm PWW (P$_2$O$_5$ sludge from clarification for MAP production)	4,000 tpd DAP; 900 tpd MAP; 18,000 gpm PWW
Granular Triple Superphosphate Production	1	54% P_2O_5; 73% BPL; 4,000 gpm PWW	1,000 tpd GTSP; 4,000 gpm PWW
Defluorination	2	600 tpd 54% P_2O_5; 16,000 gpm PWW	Defluorinated 54% P_2O_5; 16,000 gpm PWW
Animal Feed Production	1	54% P_2O_5; Limestone; Ammonia; 7,000 gpm PWW	2,500 tpd of Dynafos, Biofos, Monofos, and Duofos; 7,000 gpm PWW
Multifos Production	1	54% P_2O_5; Soda Ash; 75% BPL; 7,000 gpm PWW	300 tpd Multifos; 7,000 gpm PWW

Notes:

Phosphoric Acid Production includes attack and filtration, evaporation, and clarification.
All process wastewater inputs are directly from the cooling pond, with the exception of 6,000 gpm of process wastewater that is sent from the defluorination evaporators to the Multifos scrubbers.
PWW = process wastewater
gpm = gallons per minute
BPL = bone phosphate of lime grade phosphate rock as pebble and concentrate
tpd = tons per day

EXHIBIT 3

Cooling Pond Water Balance at IMC Fertilizer



A2-11

EXHIBIT 4
Process Flow Diagram for IMC Fertilizer

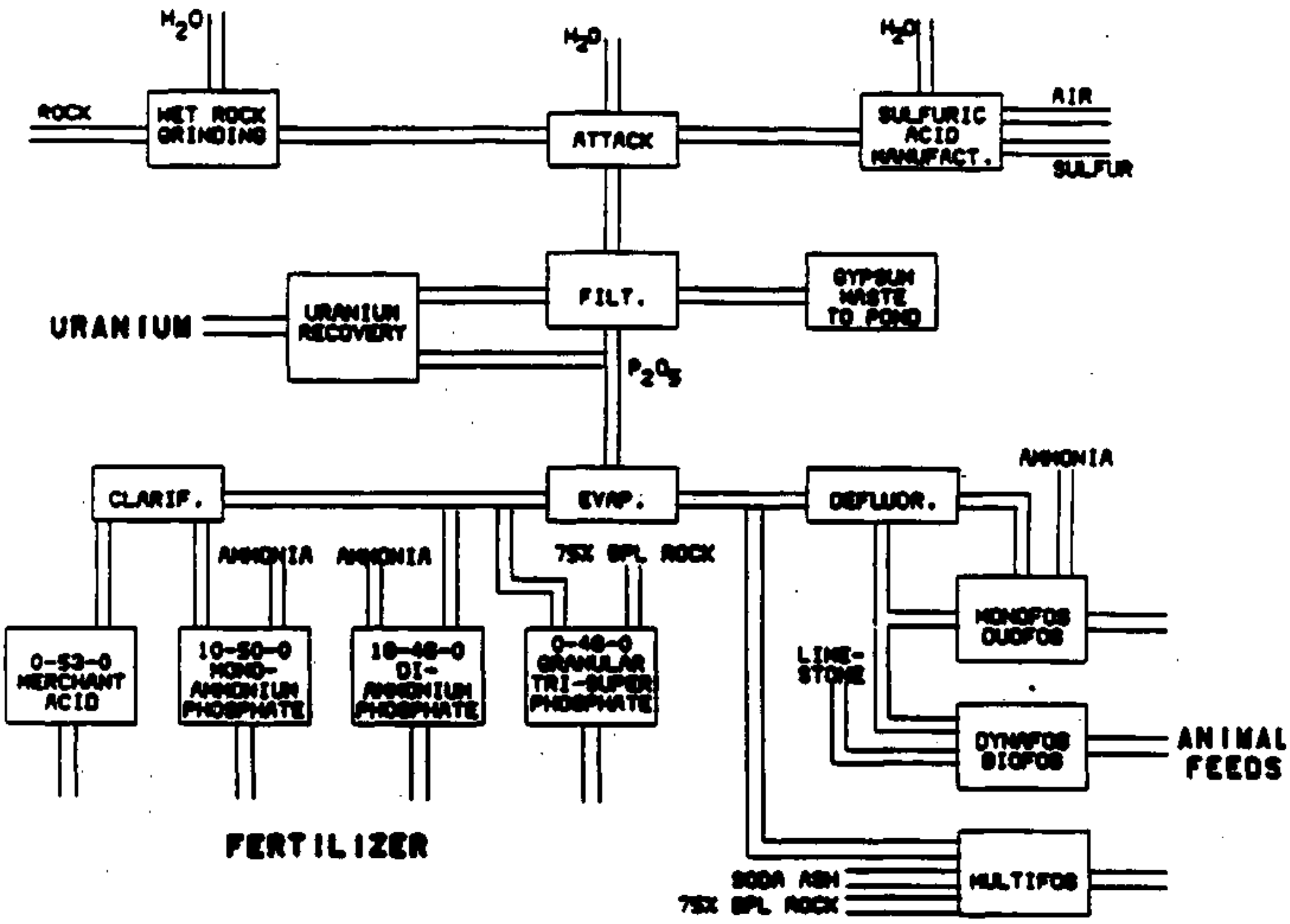
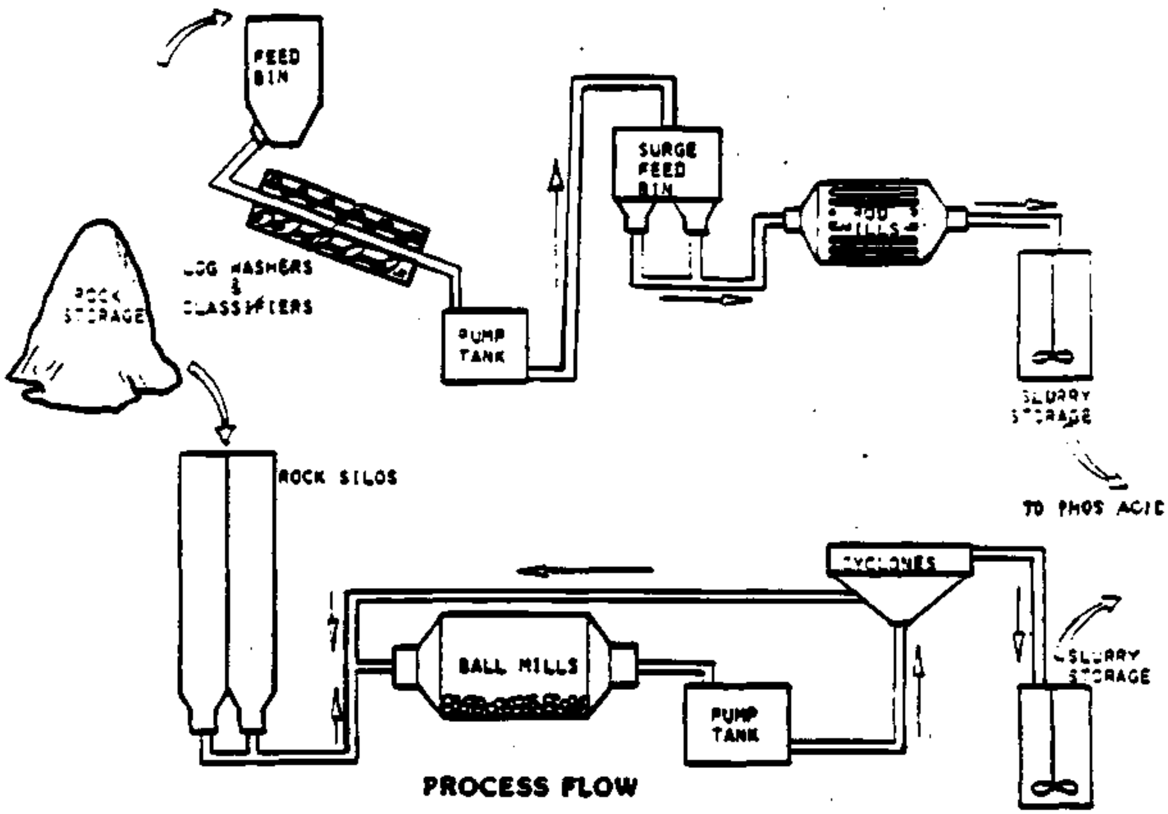


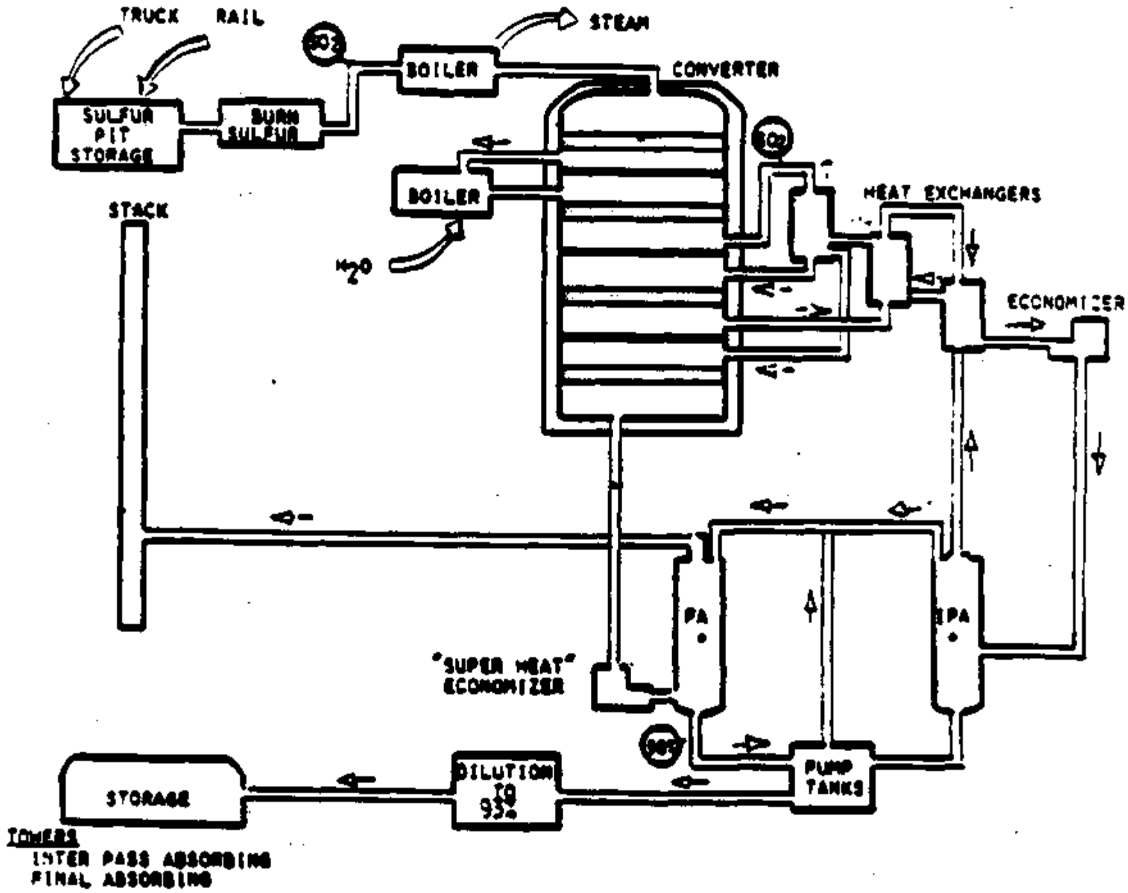
EXHIBIT 5
Wet Rock Grinding Process Flow



PROCESS FLOW

A2-13

EXHIBIT 6
Sulfuric Acid Plant Process Flow



A2-14

EXHIBIT 7
Phosphoric Acid Plant Process Flow

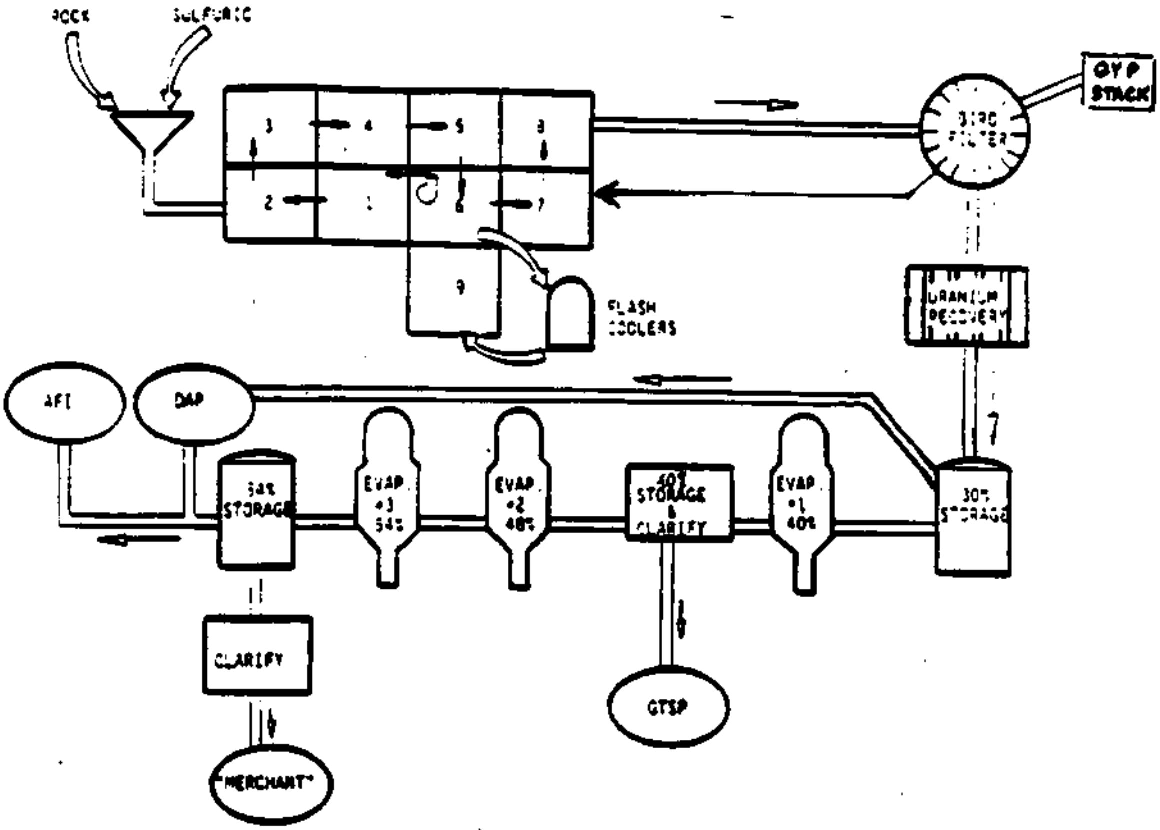
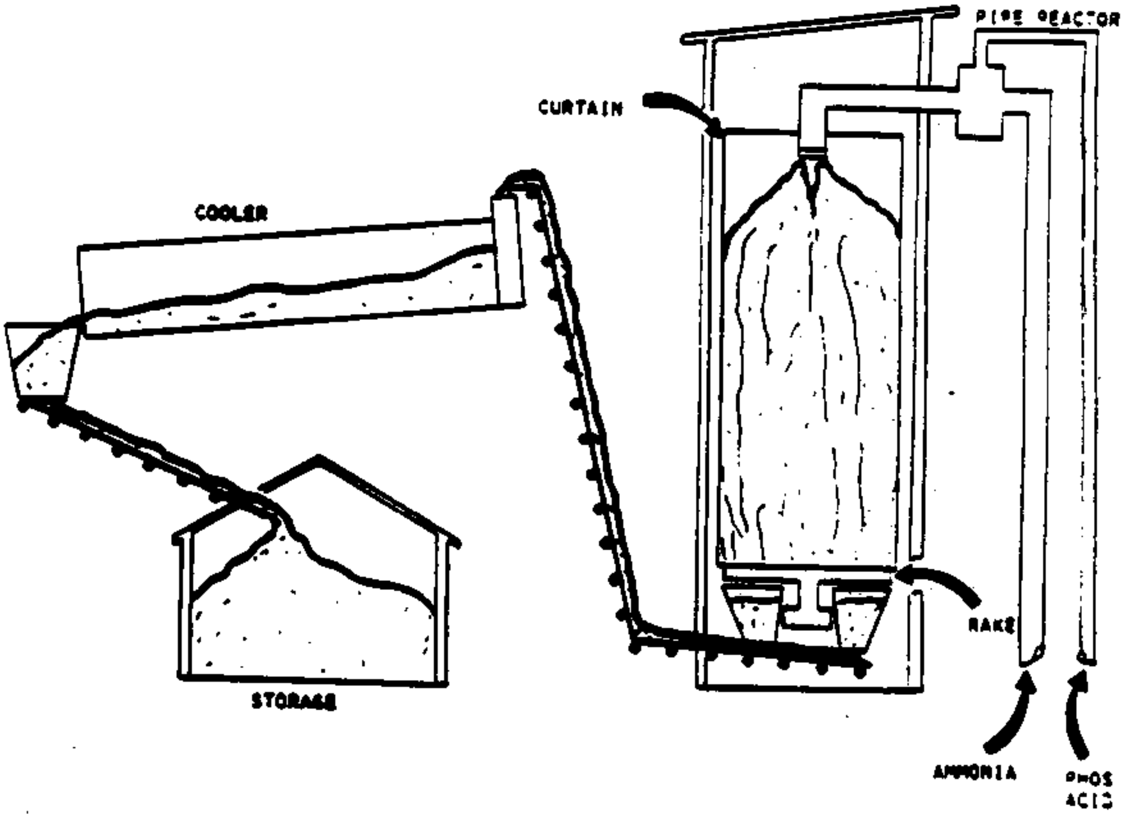
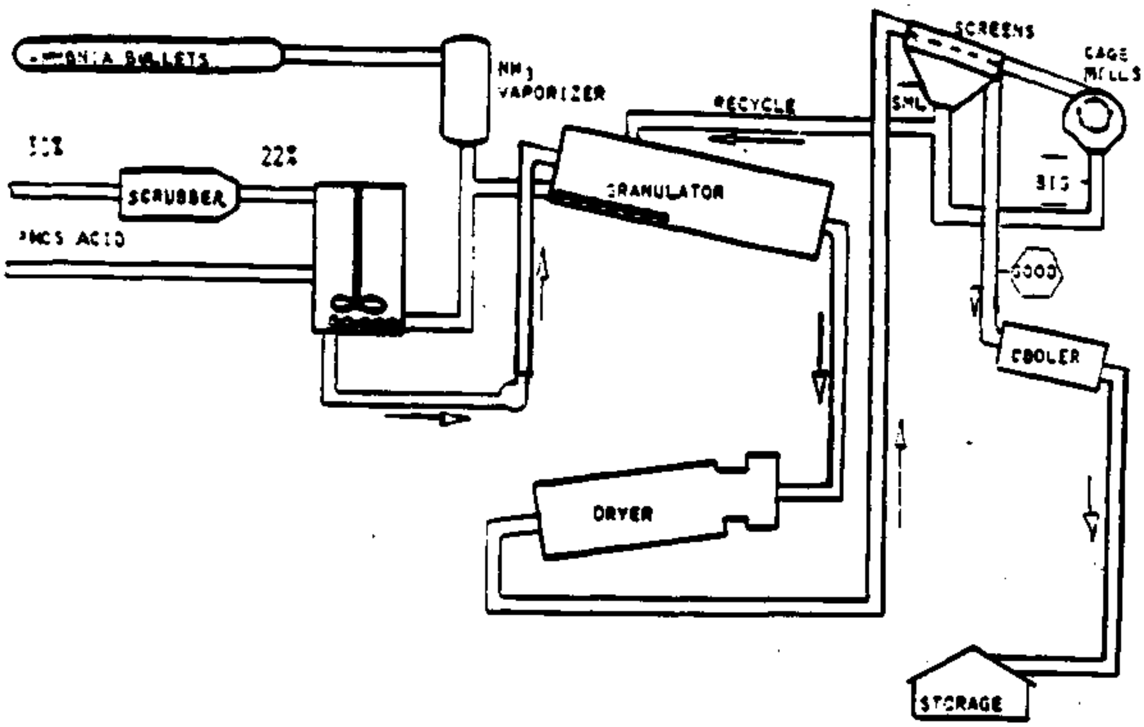


EXHIBIT 8
Monoammonium Phosphate Plant Process Flow



A2-16

EXHIBIT 9
Diammonium Phosphate Plant Process Flow



A2-17

EXHIBIT 10
Granular Triple Super Phosphate Process Flow

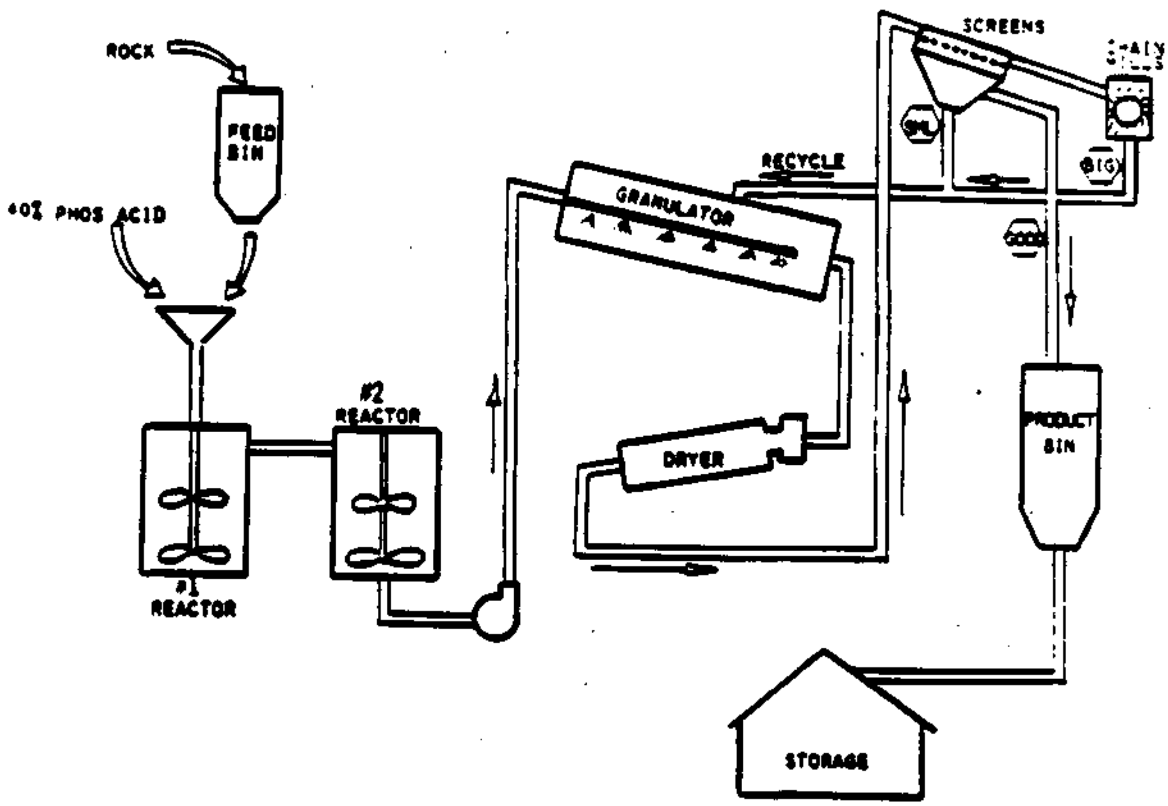
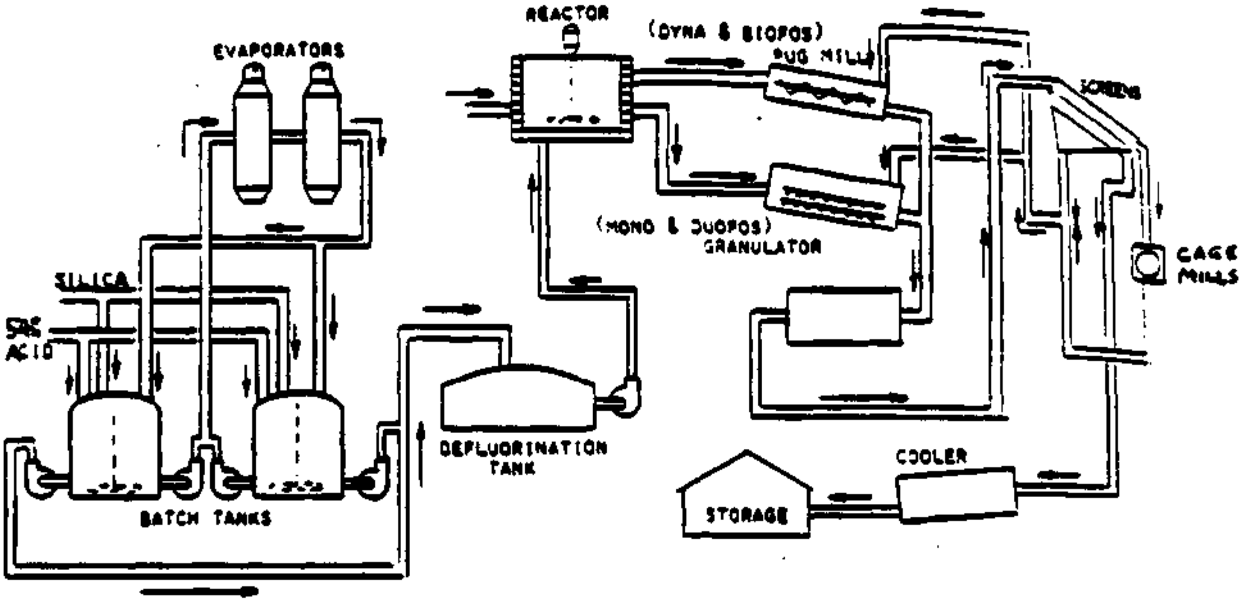


EXHIBIT 11
Animal Feed Plant Process Flow



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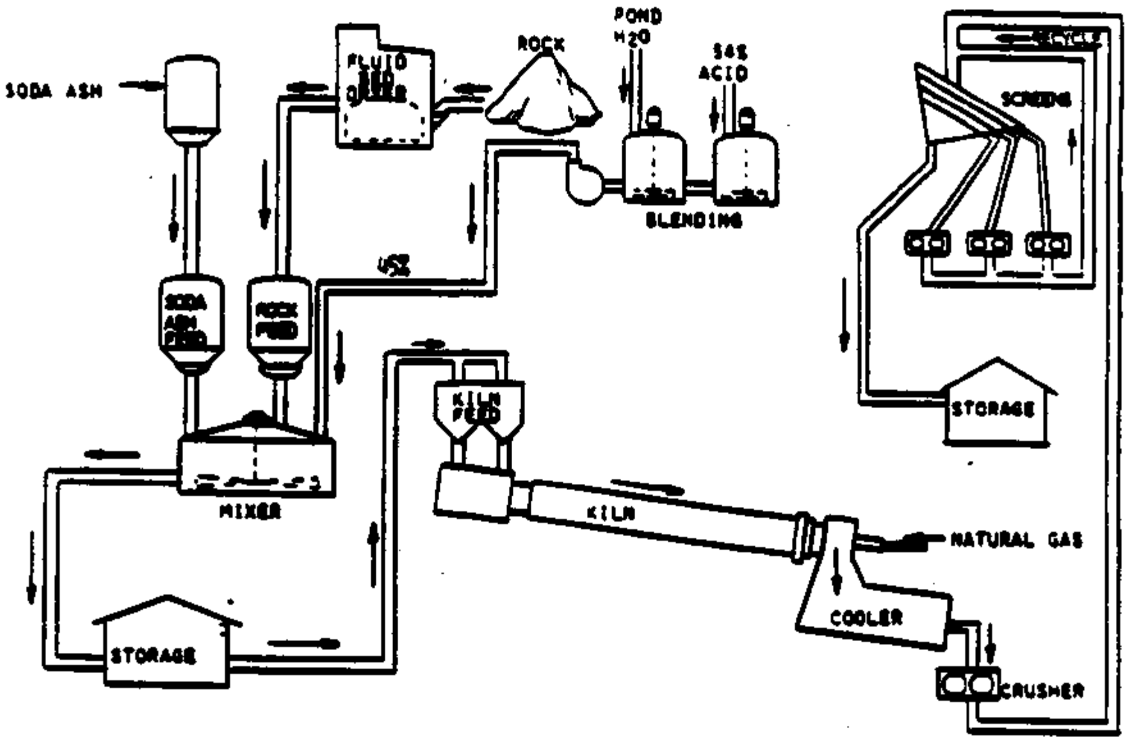
A2-19

EXHIBIT 12
Multifos Plant Process Flow



* * * DRAFT — November 16, 1990 * * *

A2-20

EXHIBIT 13
Cooling Pond Water Demand of Plant Operations

IMC Fertilizer--New Wales Operations

Gypsum Pond Water System

Wetrock Grinding

300-500 gpm total to grind rock in four mills (in addition to about 1000 gpm of utility pond water. This pond water proceeds with the rock to the PhosAcid attack tanks. This recovers P_2O_5 and H_2SO_4 and helps maintain the pond level.

PhosAcid Attack and Filtration

3000 gpm to make PhosAcid. This is fed across the three tilting pan filters as wash water to recover P_2O_5 or added directly to the three attack tanks. This recovers P_2O_5 and H_2SO_4 and helps maintain the pond level.

25,000 gpm to condense vapors from two flash coolers in each of the three trains, using barometric condensers. Recycled to cooling pond.

6,000 gpm to scrub fluorine vapors from three trains using one fume scrubber each. Recycled to cooling pond.

16,000 gpm to sluice and convey gypsum from the three trains to the gypsum pile. Recycled to cooling pond.

PhosAcid Evaporation

60,000 gpm to condense vapors from 12 evaporators using barometric condensers. Recycled to cooling pond.

PhosAcid Clarification

0-2,000 gpm to scrub pipelines on down days. Recycled to cooling pond.

0-2,000 gpm for indirect cooling of PhosAcid for merchant acid production. Recycled to cooling pond.

500 gpm to scrub vapors from storage tanks using a fume scrubber. Recycled to cooling pond.

0-50 gpm as wash water on each of two belt filters. Recovered to the attack tanks. This recovers P_2O_5 and H_2SO_4 and helps maintain the pond level.

MAP

0-25 gpm to make MAP. Used first to scrub vapors from the MAP prill tower, then pumped to the prill tower. This recovers P_2O_5 and H_2SO_4 and helps maintain the pond level.

DAP1

4,000 gpm to scrub vapors from the DAP equipment using one fume scrubber. Recycled to cooling pond.

0-100 gpm used to make DAP. Added to the primary scrubbers and then pumped to the reactor. This recovers P_2O_5 and H_2SO_4 and helps maintain the pond level.

GTSP

4,000 gpm to scrub vapors from GTSP equipment and the storage building using four fume scrubbers. Recycled to cooling pond.

0-50 gpm used to make GTSP. Added to the reactor. This recovers P_2O_5 and H_2SO_4 and helps maintain the pond level.

DAP2

14,000 gpm to scrub vapors from DAP equipment using four fume scrubbers. Recycled to cooling pond.

0-200 gpm used to make DAP. Added to the primary scrubbers and pumped to the reactors. This recovers P_2O_5 and H_2SO_4 and helps maintain the pond level.

0-100 gpm used to neutralize an ammoniated condensate stream for use in wetrock grinding. This recovers P_2O_5 and H_2SO_4 and helps maintain the pond level.

Shipping

0-50 gpm to scrub dusty gases from the shipping equipment using a scrubber. Recycled to cooling pond.

Uranium

3,000 gpm for indirect cooling of PhosAcid. Recycled to cooling pond.

0-100 gpm for indirect cooling of feed to the refinery. Recycled to cooling pond.

500 gpm to scrub vapors from equipment using two fume scrubbers. Recycled to cooling pond.

Defluorination

16,000 gpm to condense vapors from two evaporators using barometric condensers. Recycled to cooling pond.

AFI

6,000 gpm to scrub vapors from AFI equipment using four fume scrubbers. Recycled to cooling pond.

Multifos

7,000 gpm to scrub vapors from Multifos equipment using three fume scrubbers. Recycled to cooling pond.

0-50 gpm to make Multifos. Added to the acid batch tanks. This recovers P_2O_5 and H_2SO_4 and helps maintain the pond level.

General--All Areas Listed Above

Pond water is used to scrub pipelines and clean up product from the floor areas of all plants. Recycled to cooling pond. This recovers P_2O_5 and H_2SO_4 and helps maintain the pond level. (Without the reuse of pond water, it would be necessary to use fresh or treated pond water for this purpose and the pond level would rise in the rainy season and possibly overflow to the surroundings.

Total Flows

The above flows add up to about 167,000 and are approximate. Some of these flows are reused within the areas more than once, in an attempt to reduce the amount of piping and pumps required. For example, Multifos uses much of its pond water for scrubbers after the Defluorination evaporators used it. This interconnection is complex, but necessary to operate New Wales at full rates.

APPENDIX A3--TRIP REPORT

U.S. AGRI-CHEMICALS/FORT MEADE, FL

TRIP REPORT

U.S. Agri-Chemicals
Ft. Meade, Florida

September 19, 1990

Introduction

EPA, along with its contractors, ICF Incorporated and SAIC, visited U.S. Agri-Chemicals (USAC) in Ft. Meade, Florida on September 19, 1990. John Martinez, a chemical engineer with Badger Design and Constructors of Tampa, also attended the meeting to assist the Agency, its representatives, and IMC in a discussion of the plant's operations. Exhibit 1 presents a list of participants in the meeting.

EPA is currently preparing a regulatory determination that will establish whether or not regulation of any of the wastes covered by the July 31, 1990 Report to Congress on Special Wastes from Mineral Processing is warranted under Subtitle C of RCRA. The Agency, in order to better make this decision, is undertaking the task of further data collection and analysis of the generation and management of process wastewater and phosphogypsum from phosphoric acid operations. Collection of additional data is being accomplished in part through visits by EPA and Agency representatives to selected phosphoric acid facilities representing three major areas of phosphoric acid production. The primary goals of the visits were (1) to gain a better understanding of the flow of water into and out of various sub-operations within phosphoric acid facilities and (2) to continue to gather information in support of the Agency's upcoming regulatory determination on the RCRA status of process wastewater and phosphogysum. Pre-trip knowledge of process wastewater flows at phosphoric acid plants was confined to the total flow of water from the plant to the various waste management operations such as cooling ponds and gypsum stacks. This visit was part of an effort by the Agency to better understand what individual streams generated within the plant make up the total flow from the plant to the management units. While waste management operations were discussed and visited, gathering additional insight into their operations was of secondary importance.

The visit consisted of a meeting in the morning during which processes and process wastewater flows were discussed; a tour of the phosphoric acid plant and associated operations during the afternoon; and a final meeting after the tour. The information gathered during those meetings and the tour is the topic of this report.

This trip report begins with an overview of U.S. Agri-Chemical's plant production operations, including inputs to the process, the types of operations, and the products generated. Next, we describe highlights of the plant's waste management practices, focusing on sources of process wastewater, uses of returning pond water, other non-process wastewater sources and uses, and management of the plant's gypsum stack and associated water. The report

concludes with flow charts and tables provided by U.S. Agri-Chemicals during the meeting.

Overview of Plant Production Operations

In 1988, U.S. Agri-Chemical's Ft. Meade Complex was the United States' tenth largest producer (among 19 producers) of phosphoric acid and phosphate fertilizer ingredients, according to the Report to Congress on Special Wastes from Mineral Processing. In 1988, the plant produced 0.5 million metric tons of P_2O_5 in the form of merchant grade (i.e., 54 percent) phosphoric acid, which was 5 percent of the total national production.

Exhibit 2 presents the types of operations, the number of units per operation, the material inputs to each operation, and the products generated by each operation. Exhibit 3 presents a generalized process flow diagram for the facility, and Exhibit 4 presents a cooling pond water balance. Exhibit 5 presents a pond water temperature profile for the facility. Exhibit 6 presents a diagram showing the balance between the cooling water pond and the gypsum stack, and Exhibit 7 presents a plan view of the pond and stack. In the following sections, we describe each of the plant operations, with emphasis placed on process and non-process wastewater flows.

Wet Rock Grinding

Utilizing two trains, USAC grinds on average 3.6 tons of wet, beneficiated 66 percent bone phosphate of lime (BPL) grade phosphate rock for each ton of P_2O_5 it produces. (The design capacity of the phosphoric acid plant is 1,400 tons per day [TPD]; thus, USAC uses about 5,000 TPD of phosphate rock.) USAC reported that the percentage of BPL in the phosphate rock feed can be as low as 62 percent, depending on the grade of ore that is received from its mines. The phosphate rock feed is ground in two ball mills at a combined rate of 250 tons per hour. These ball mills use 346 gallons per minute (gpm) of cooling pond water in the grinding circuit.

Sulfuric Acid Plants

USAC produces sulfuric acid in two identical double absorption contact sulfuric acid manufacturing plants, designed and constructed in 1982. Each plant has a capacity of 2,000 TPD (approximately 1.4 million tons per year for both plants) of 98 percent sulfuric acid (H_2SO_4).

USAC manufactures its H_2SO_4 in the same manner as most phosphoric acid plants, that is, molten sulfur is burned with air, producing gaseous sulfur dioxide, nitrogen, and oxygen. This gas passes through a boiler where steam and a blowdown of pH 11 to 12 are generated. (USAC generates about 32 megawatts of power in the manufacture of H_2SO_4. Steam generated in the process is used in the evaporation of 29 percent P_2O_5 to 52 percent P_2O_5.) The sulfur dioxide gas is then converted to gaseous sulfur trioxide by reactions with air in a converter in a series of four conversions in the presence of a vanadium pentoxide catalyst. (USAC formerly disposed of spent catalysts on its gypsum stack but now returns them to the catalyst manufacturer for

...le.) After three conversion steps that convert the sulfur dioxide to sulfur trioxide, the gas is reacted with water and sulfuric acid in absorption towers to produce 98 percent H_2SO_4. The final H_2SO_4 stream is cooled in a cooling tower, creating a blowdown of Ph 7 that is sent to the cooling pond.

<u>Phosphoric Acid Plants</u>

Attack and Filtration

USAC operates two wet process phosphoric acid trains that have a combined capacity of 1,400 tons of P_2O_5 per day, approximately 500,000 tons per year. The two trains are identical in construction and consist of rock grinding, reaction, and filtration units.

USAC utilizes an isothermal reactor for the reaction between phosphate rock slurry and sulfuric acid. Reaction vapors are condensed in barometric condensers that use pond water. Reactor vacuum pump scrubbers also use pond water to remove fumes from the air before it is released to the atmosphere. USAC returns about 200 gpm of condensed water to the cooling pond from this stage.

USAC separates phosphoric acid from the gypsum created in the reaction stage with UCEGO rotating table filters. The filters are under vacuum and utilize pond water in their filter vacuum scrubbers. After vacuum filtration, USAC performs three washings of the gypsum cake with recycled pond water to recover phosphoric acid entrained in the pore space of the gypsum. About 1.5 percent of the total P_2O_5 recovery is estimated from the incoming pond water. As the gypsum is removed from the filter it is sluiced with 6,000 gpm of pond water to make a gypsum slurry that is pumped to the gypsum stack.

At the time of EPA's visit, USAC reported a total recovery from the filtration stage of 93 percent of the P_2O_5 fed to the reactor in the rock slurry. The seven percent loss was attributed to insoluble losses of 4.2 percent in the gypsum and water-soluble acid losses in the gypsum pore water of 2.8 percent. USAC reported that total P_2O_5 recovery can be as high as 95 percent.

Evaporation

After filtration, the 29 percent P_2O_5 product stream ("mother liquor") is clarified and held in storage tanks prior to evaporation. As described above, USAC utilizes steam from the sulfuric acid plant to evaporate excess water from acid in order to concentrate it. USAC utilizes two evaporators for each production train. The product stream is concentrated in a dual-stage vacuum evaporation process to increase the acid concentration first from 29 percent to 40 percent and then from 40 percent to 54 percent P_2O_5 concentration. Vapors are drawn off by vacuum. USAC maintains a maximum temperature of 185°F to protect the inside rubber lining of the vessels in the evaporation step.

USAC recovers 25 percent fluosilicic acid (H_2SiF_6, also known as FSA) as a by-product from the phosphoric acid evaporators and from reaction vapors evolved from the reaction stage. Fluorine compounds are recovered from the vapor in fluosilicic absorption towers at a rate of 55 tons per day (approximately 20,000 tons annually). Seventy-five percent of the fluoride present in the vapors is removed. USAC sells its recovered fluosilicic acid to a nearby Alcoa plant that manufactures aluminum fluoride. After FSA is removed, the vapors are condensed in barometric condensers and sent to the cooling water pond.

Clarification and Storage

USAC removes solids from the phosphoric acid product with one of four clarifiers. Phosphoric acid is stored in five tanks grouped in a tank farm.

Highlights of Waste Management Practices

USAC returns an average of 36,000 gpm of process wastewater from its cooling pond to the phosphoric acid plant (Exhibits 4 and 5). The majority of this water is sent to the barometric condensers dedicated to the 54 percent evaporators, where it flows into a sump. (A smaller quantity of pond water is sent to fume scrubbers that scrub fumes at the tops of the tanks in the tank farm.) Water is pumped from the sump to the barometric condensers dedicated to the 40 percent evaporators and to the barometric condensers and scrubbers dedicated to the reactor. Any excess water is returned to the cooling pond. Water condensed from vapors evolved during the reaction stage are sent to the filtration area where it is used in filter vacuum scrubbers, to wash the gypsum cake and the filter cloth, and to sluice the filtered gypsum to the stack. USAC returns an average of 30,000 gpm of process wastewater to the cooling pond via a trench system, with the remaining 6,000 gpm used to slurry the gypsum to the stack.

Process wastewater enters the cooling pond at temperatures between 110°F and 120°F and cools to between 80°F and 90°F before it is returned to the plant.

USAC utilizes a gypsum stack to store the approximately 7,000 TPD to 8,000 TPD of gypsum it generates. Transport water used to convey the gypsum to the stack leaches through the stack and collects in a reclaim pond and is conveyed via trenches to the cooling pond.

USAC reported that because a negative water balance across the stack/pond system has been maintained since the beginning of operations in 1982, no pond water has been treated and discharged from the system through the facility's NPDES outfall.

EXHIBIT 1
List of Attendees -- U.S. Agri-Chemicals, September 19, 1990

	Organization	Phone Number
P K Battacharjee	U.S. Agri-Chemicals	(813) 285-8121, x272
Jim Carroll	U.S. Agri-Chemicals	(813) 285-8121, x239
Xu Jing Ming	U.S. Agri-Chemicals	(813) 285-8121, x257
Kim Norgard	U.S. Agri-Chemicals	(813) 285-8121, x270
Van Houseman	US EPA/OSW	(202) 475-7241
Larry Huffman	ICF Incorporated	(703) 934-3382
Peter Soyka	ICF Incorporated	(703) 934-3619
Larry Lai	SAIC	(703) 734-3195
Karl Johnson	The Fertilizer Institute	(202) 675-8275
John Martinez	Badger Design and Constructors, Inc.	(813) 289-1991

EXHIBIT 2
Operations, Inputs, and Outputs/Products at U.S. Agri-Chemicals

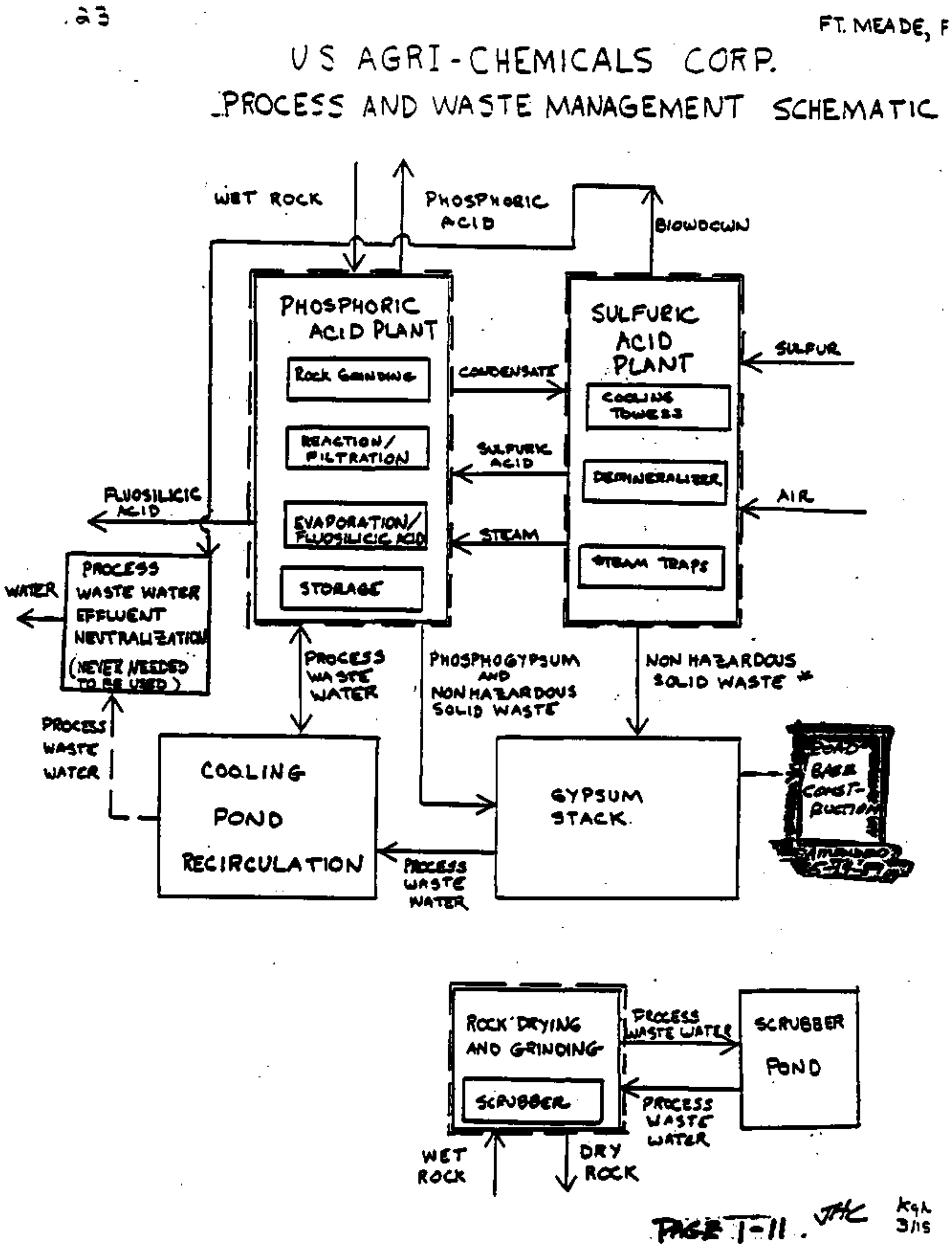
Operation	Number of Units	Inputs	Outputs/Products
Wet Rock Grinding	2 trains	5,000 TPD 67% BPL; 345 gpm PWW	Rock slurry to phosphoric acid attack tanks
Sulfuric Acid Production	2 plants	Molten sulfur	4,000 TPD 98% H_2SO_4; cooling tower blowdown
Phosphoric Acid Production	2 trains	Phosphate rock slurry; 98% H_2SO_4; PWW (quantity unknown)	1,400 TPD 54% P_2O_5 for sale (merchant grade); 7,000-8,000 TPD gypsum; 630 gpm PWW (net to pond)
Fluosilicic Acid Recovery	2 absorption towers (1 per train)	Vapors from reactor and evaporators (quantity unknown)	55 TPD 25% H_2SiF_6

Notes:

Phosphoric Acid Production includes attack and filtration, evaporation, and clarification.
All process wastewater inputs are directly from the cooling pond.
PWW = process wastewater
gpm = gallons per minute
BPL = bone phosphate of lime grade phosphate rock as pebble and concentrate
TPD = tons per day

EXHIBIT 3

Process Flow Diagram for U.S. Agri-Chemicals



APPROX. POND WATER BALANCE AT FMCP

POND WATER IN, GPM		POND WATER OUT, GPM	
1. WATER THRU' GYP. SLURRY	6,000	1. WATER RETAINED IN CAKE	448
2. SEEPAGE WATER	23	2. PROC. WATER RETURN	36,000
3. PROCESS WATER IN	30,000	3. SOLAR EVAP'N(GYP. POND)	390
4. RAIN FALL	1,353	4. SOLAR EVAP'N(COOLING POND)	280
5. WASH WATER	25	5. PROC. HEAT EVAP'N	487
6. DEFICIT WATER	204		
TOTAL	37,605	TOTAL	37,605

EXHIBIT 4
Cooling Pond Water Balance

A3-8

P.2

A3-9

EXHIBIT 5
Pond Water Temperature Profile

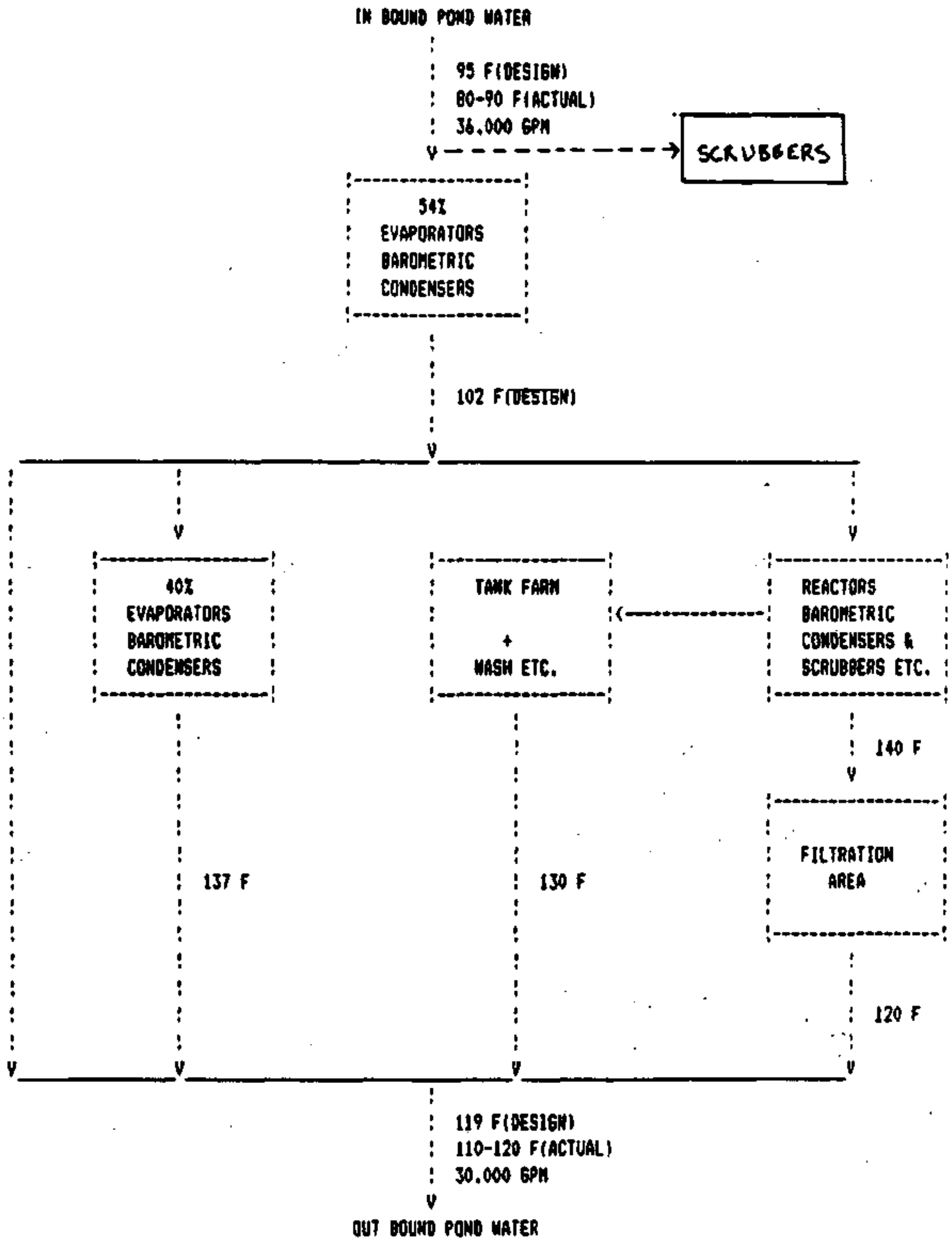


EXHIBIT 6

Gypsum Stack and Cooling Pond Water Balance

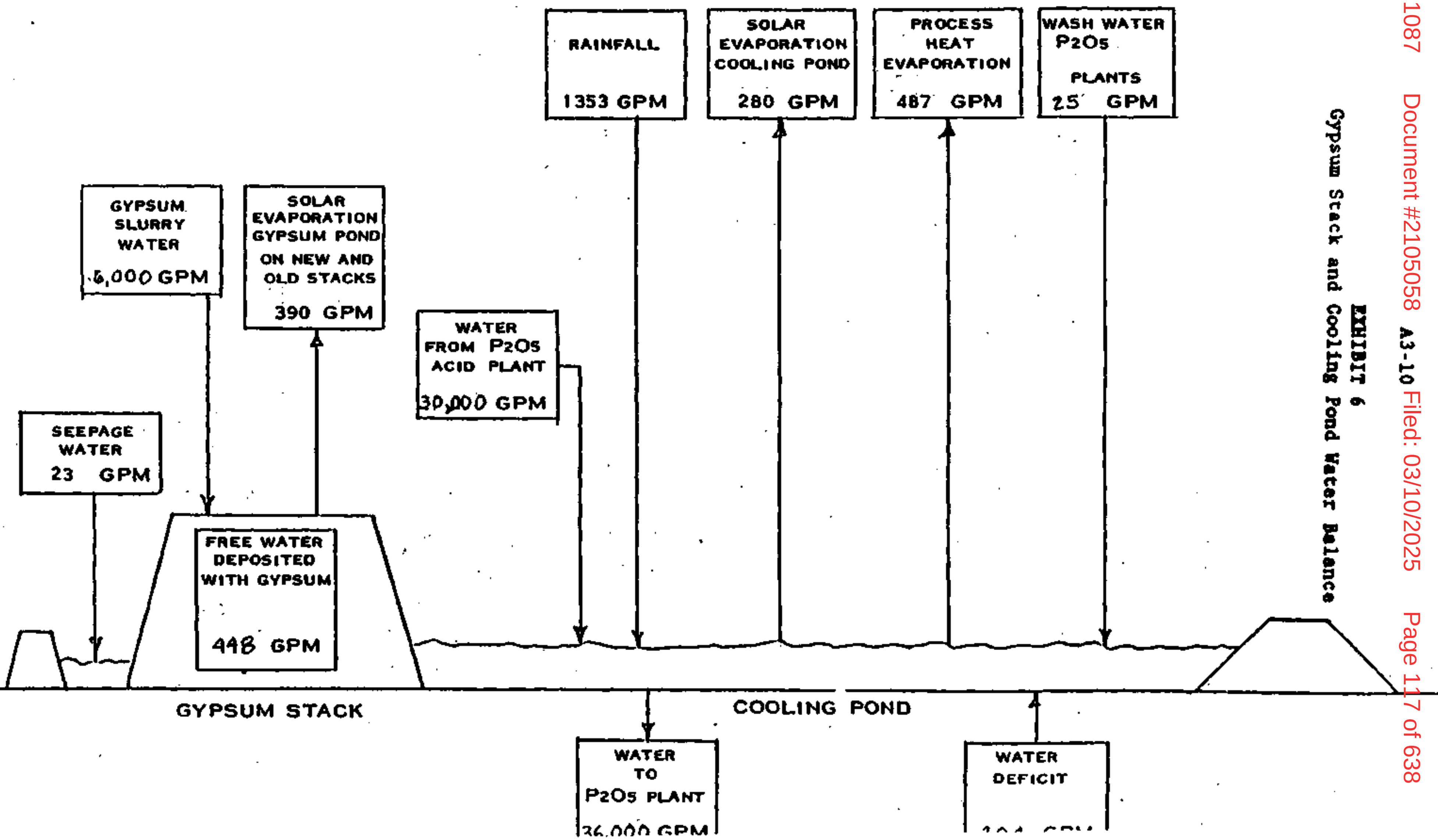
US Agri-Chemicals

A Sinochem Company

09/14/90

GYPSUM STACK AND COOLING POND WATER BALANCE - AFTER 8 YEARS OF OPERATION

NOTE: ALL GPM BASED ON 319 DAYS PER YEAR



P.4

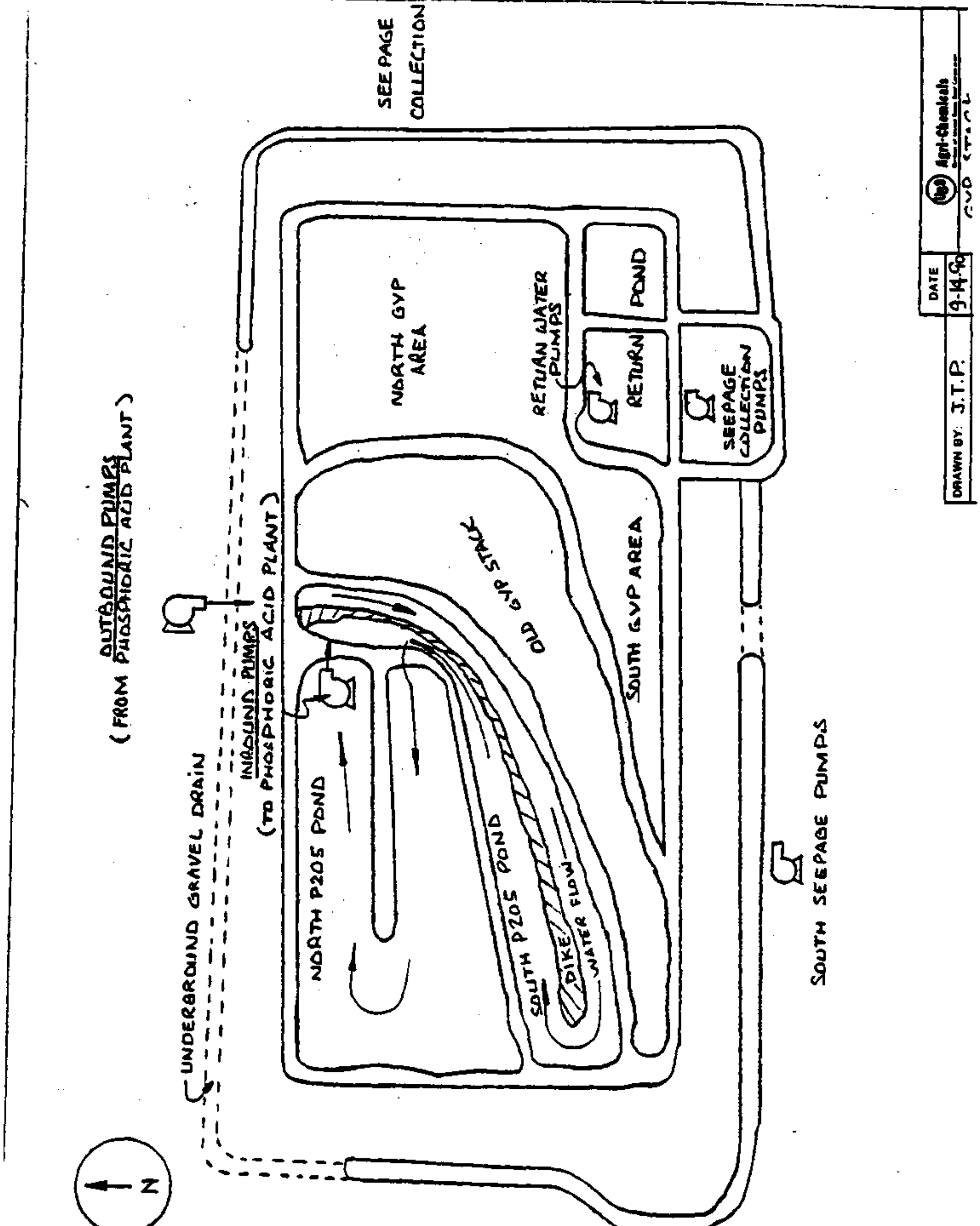


EXHIBIT 7
Plan View of Gypsum Stack and Cooling Pond

APPENDIX A4—TRIP REPORT

GARDINIER/RIVERVIEW, FL

plant's waste management practices, focusing on Gardinier's closure of its old gypsum stack and the construction of its new gypsum field. The report concludes with a flow chart and a map provided by Gardinier during the meeting.

Overview of Plant Production Operations

In 1988, Gardinier was the United States' fifth largest producer (among 19 producers) of phosphoric acid and phosphate fertilizer ingredients, according to the Report to Congress on Special Wastes from Mineral Processing. In 1988, the plant produced 0.6 million metric tons of P_2O_5 in the form of merchant grade (i.e., 54 percent) phosphoric acid, which was 6 percent of the total national production. Gardinier is located on the eastern shore of Tampa Bay on approximately 2,600 acres near Riverview and Gibsonton in Hillsborough County. Operations began at the facility in 1924.

Exhibit 2 presents a generalized process flow diagram for the facility, and Exhibit 3 presents a map of the facility. In the following sections, we present a brief overview of the plant operations.

Gardinier receives phosphate rock from its mine located 55 miles from the facility. Gardinier uses ball mills to grind the wet phosphate rock to a slurry of 68 percent solids. The slurry is stored in tanks before it is sent to the phosphoric acid plants. Untreated blowdown from the sulfuric acid plant cooling towers and seal water from vacuum pumps are the primary sources of water used in the ball mills.

Gardinier manufactures its H_2SO_4 in the same manner as most phosphoric acid plants; a description of this process can be found in the IMC and USAC trip reports.

Gardinier operates two wet process phosphoric acid trains that have a combined capacity of approximately 1,800 tons of P_2O_5 per day, approximately 600,000 tons per year. Gardinier manufactures merchant grade (54 percent) phosphoric acid, diammonium phosphate, monoammonium phosphate, and granular triple superphosphate.

Gardinier uses two Bird tilting pan filters, one for each train, in its filtration stage. Gardinier reported a P_2O_5 recovery from the filter of 92 percent, with 4.5 percent insoluble P_2O_5 losses to the gypsum and 3.5 percent water soluble P_2O_5 losses due to inefficient washing of the gypsum cake. Gardinier further reported that 80 percent of the water soluble losses precipitate out as the gypsum transport water passes across the gypsum field; they conclude that only 20 percent of the 3.5 percent water soluble loss could be recovered by return from the cooling pond to the production process. Gardinier is currently examining the possibility of adding a new filter that may reduce the water soluble losses from 3.5 percent to one percent, with a one-year payback in terms of recovering more of the P_2O_5 product.

A4-1

TRIP REPORT

Gardinier, Inc.
Riverview, Florida

September 21, 1990

Introduction

EPA, along with its contractors, ICF Incorporated and SAIC, visited Gardinier, Inc. in Riverview, Florida on September 21, 1990. John Martinez, a chemical engineer with Badger Design and Constructors of Tampa, also attended the meeting to assist the Agency, its representatives, and IMC in a discussion of the plant's operations. Exhibit 1 presents a list of participants in the meeting.

EPA is currently preparing a regulatory determination that will establish whether or not regulation of any of the wastes covered by the July 31, 1990 Report to Congress on Special Wastes from Mineral Processing is warranted under Subtitle C of RCRA. The Agency, in order to better make this decision, is undertaking the task of further data collection and analysis of the generation and management of process wastewater and phosphogypsum from phosphoric acid operations. Collection of additional data is being accomplished in part through visits by EPA and Agency representatives to selected phosphoric acid facilities representing three major areas of phosphoric acid production. The primary goals of the visits were (1) to gain a better understanding of the flow of water into and out of various sub-operations within phosphoric acid facilities and (2) to continue to gather information in support of the Agency's upcoming regulatory determination on the RCRA status of process wastewater and phosphogypsum. Pre-trip knowledge of process wastewater flows at phosphoric acid plants was confined to the total flow of water from the plant to the various waste management operations such as cooling ponds and gypsum stacks. This visit was part of an effort by the Agency to better understand what individual streams generated within the plant make up the total flow from the plant to the management units. While waste management operations were discussed and visited, gathering additional insight into their operations was of secondary importance.

A large part of the visit to Gardinier was devoted to discussion of Gardinier's closure of its old gypsum stack and construction of its new gypsum field. The visit consisted of a meeting in the morning during which these topics were discussed; a tour of the new field and the old stack; and a final meeting after the tour, during which the production process was discussed, with emphasis placed on Gardinier's operation of its filter and fluosilicic acid recovery system. The information gathered during those meetings and the tour is the topic of this report.

This trip report begins with a brief overview of Gardinier's plant production operations, including inputs to the process, the types of operations, and the products generated. Next, we describe highlights of the

HDPE pipes convey gypsum slurry from the plant to the field. Each of the drainage pipes is encased in sand. If a pipe should fail, the sand vein connects to a blanket drain under the starter dike that runs to the leachate pit. Dry transport of gypsum from the phosphoric acid plant to the stack has not been employed by Gardinier due to the high cost of the conveyor belt system required.

New cooling ponds, when constructed, would come under the same DER regulations as the new gypsum stack.

Closure of Old Gypsum Stack

Commercial use of the old gypsum stack ended in January 1990. The stack covers 340 acres, with a surface area of 100 acres on the top, and a height of 200 feet. The lower slope has a 1:4 grade, while the upper slope has a 1:3 grade. Approximately 1.5 million gallons of process wastewater (gypsum transport water) are currently stored in the stack, with one million gallons expected to drain out of the stack and 0.5 million gallons expected to remain perched (mounded) in the stack. It is expected that mounding will resist hydraulic conductivity, preventing drainage.

Replacement of the toe drain began in 1987. The fluorine content is much less in toe-drain water than in pond water, because it is entrained in the gypsum. The recycle method is employed to maximize use of the toe-drain water and make up any difference with pond water. The toe drain drains two six-inch diameter HDPE pipes. As leachate migrates horizontally, it reaches the sand vein. During high tide there is an intrusion of salt water into the stack's western edge. Gardinier has constructed three NPDES outfalls for stormwater.

Cover soil is a clay sand, 25 percent of which are fines, with low organic matter and good moisture retention. Gardinier grassed the stack prior to 1983 due to a Consent Order. Some fires have occurred during dry periods. Roads surrounding the stack are being regraded to convey drainage away from the stack.

Two lysimeters to the north and south of the stack will provide monitoring for four years. In 1990, which was a relatively dry year, the monitors reported zero infiltration. Specified ground-water monitoring wells shall be sampled quarterly for primary and secondary drinking water parameters. A total of $30 million has been spent on ground-water protection at the new field.

Sources of Process Water

The primary source of makeup water for the ball mill is a fresh water spring located 11 miles from the plant. Approximately 1,100 gallons per minute (gpm) of water reclaimed from rainfall are also used in the plant. The plant uses between 2,800 gpm to 3,000 gpm of noncontact cooling water and currently discharges about 2,000 gpm of non-contact cooling water. Up to

Gardinier recovers fluosilicic acid off its evaporators and the reactor; it currently supplies 70 percent of the U.S. market for drinking water fluoridation.

Gardinier no longer recovers uranium due to the fact that it was not a profitable operation.

Highlights of Waste Management Practices

During the site visit, Gardinier officials escorted EPA and its representatives on a tour of the facility's new gypsum field and the old gypsum stack, which was undergoing closure. Observations made and information collected during the tour, as well as information obtained from Gardinier and state officials subsequent to the visit, are presented below.

Construction of New Gypsum Stack

In the late 1970's, Gardinier pursued permits for a new gypsum stack through the Development of Regional Impact (DRI). Gardinier has a closure permit, operating permit (which includes a provision for ground-water and surface-water monitoring), and construction permits from the Florida Department of Environmental Regulation (DER).

Operation of two phases began in January 1990 and are now complete. Phase 1 used 170 acres and Phase 2, 160 acres, for a total of 330 acres. The field has a prepared base on which to dispose the gypsum. This base is shaped in a concave fashion, with the center rising over 6 feet from the perimeter. Based on the size of the old stack, the new stack will probably be dry stack. Grading of stack top is to provide positive drainage. Controls are in place to hold water on the stack. Excess water can be removed with a recycle pipe. Saltwater inversion from Tampa Bay occurs at the western toe of the gypsum field. Dewatering to equilibrium should occur in 50 years.

Water storage is critical on the new gypsum stack. Dry stacks pose the problem of slumping, which leads to instability. The stack is dry because it drains too well, resulting in a 300 gpm to 400 gpm negative water balance. Gypsum does not compact readily without moisture, and the facility would have to limit stack heights and increase area. There are varying degrees of compaction throughout the stack.

Storm water runoff is handled by a retention wall between the gypsum and starter dike. A second retention wall at the outer toe of the starter dam takes runoff from the first reinforcement to through a sand drain and recycles it back to the system. The slurry wall surrounds the swales.

Eight sets of monitoring wells surround the field. Plate monitors provide upstream and downstream surface-water monitoring on a continous basis. Prior to employment of the new gypsum stack, Gardinier collected more than two years of background monitoring data.

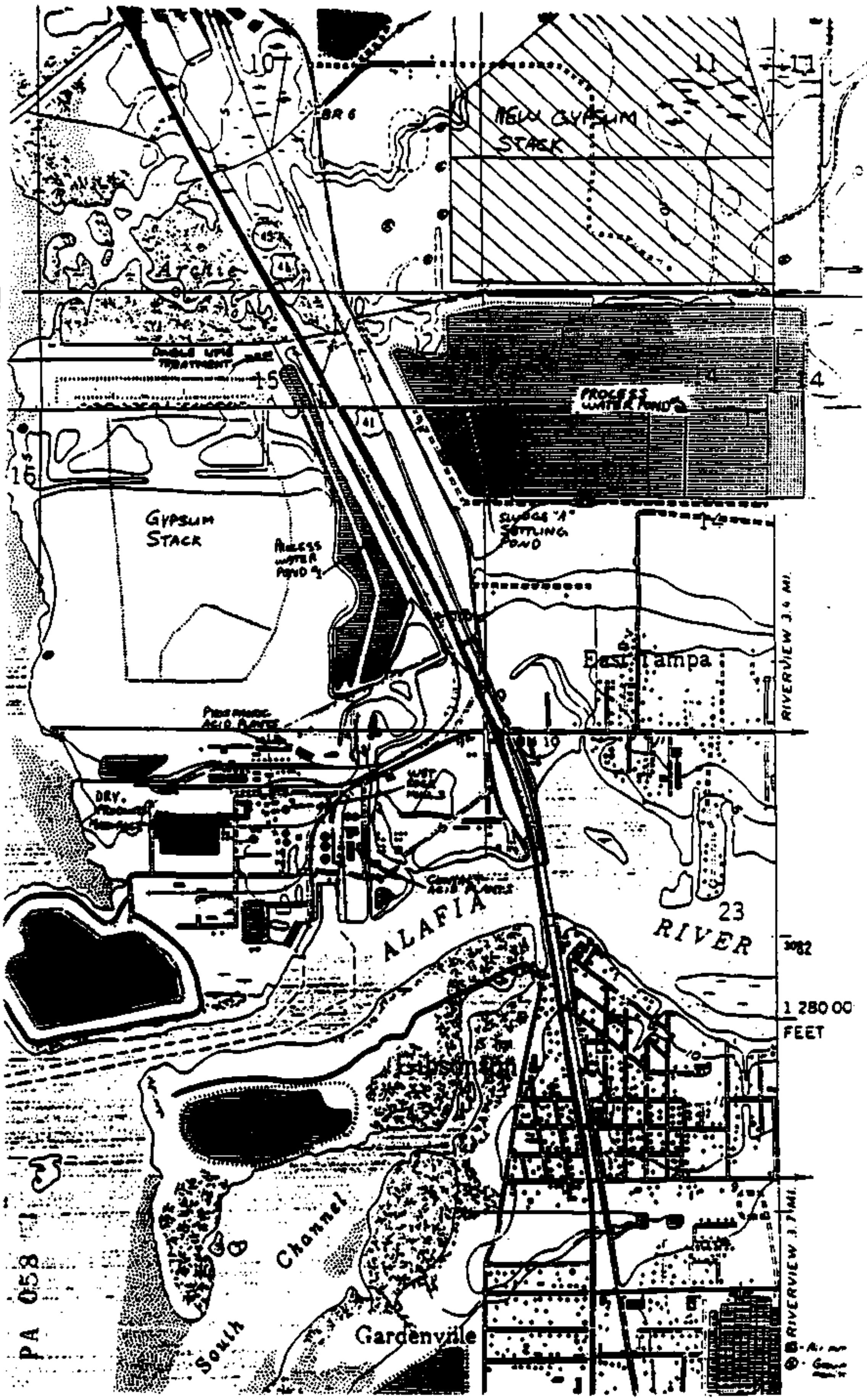
EXHIBIT 1
List of Attendees -- Gardinier, Inc., September 20, 1990

	Organization	Phone Number
Don Clark	Gardinier, Inc.	(813) 677-9111
David Jellerson	Gardinier, Inc.	(813) 671-6207
Dean Kleinschmidt	Gardinier, Inc.	(813) 671-6155
Ozzie Morris	Gardinier, Inc.	(813) 671-6153
Van Houseman	US EPA/OSW	(202) 475-7241
Larry Huffman	ICF Incorporated	(703) 934-3382
Peter Soyka	ICF Incorporated	(703) 934-3619
Larry Lai	SAIC	(703) 734-3195
Karl Johnson	The Fertilizer Institute	(202) 675-8275
John Martinez	Badger Design and Constructors, Inc.	(813) 289-1991

1.000 gpm of process wastewater is recycled from the cooling pond back to the plant.

EXHIBIT 3

Map of the Gardinier Site



PA 058

PRODUCTION PROCESS & WASTE MANAGEMENT SCHEMATIC

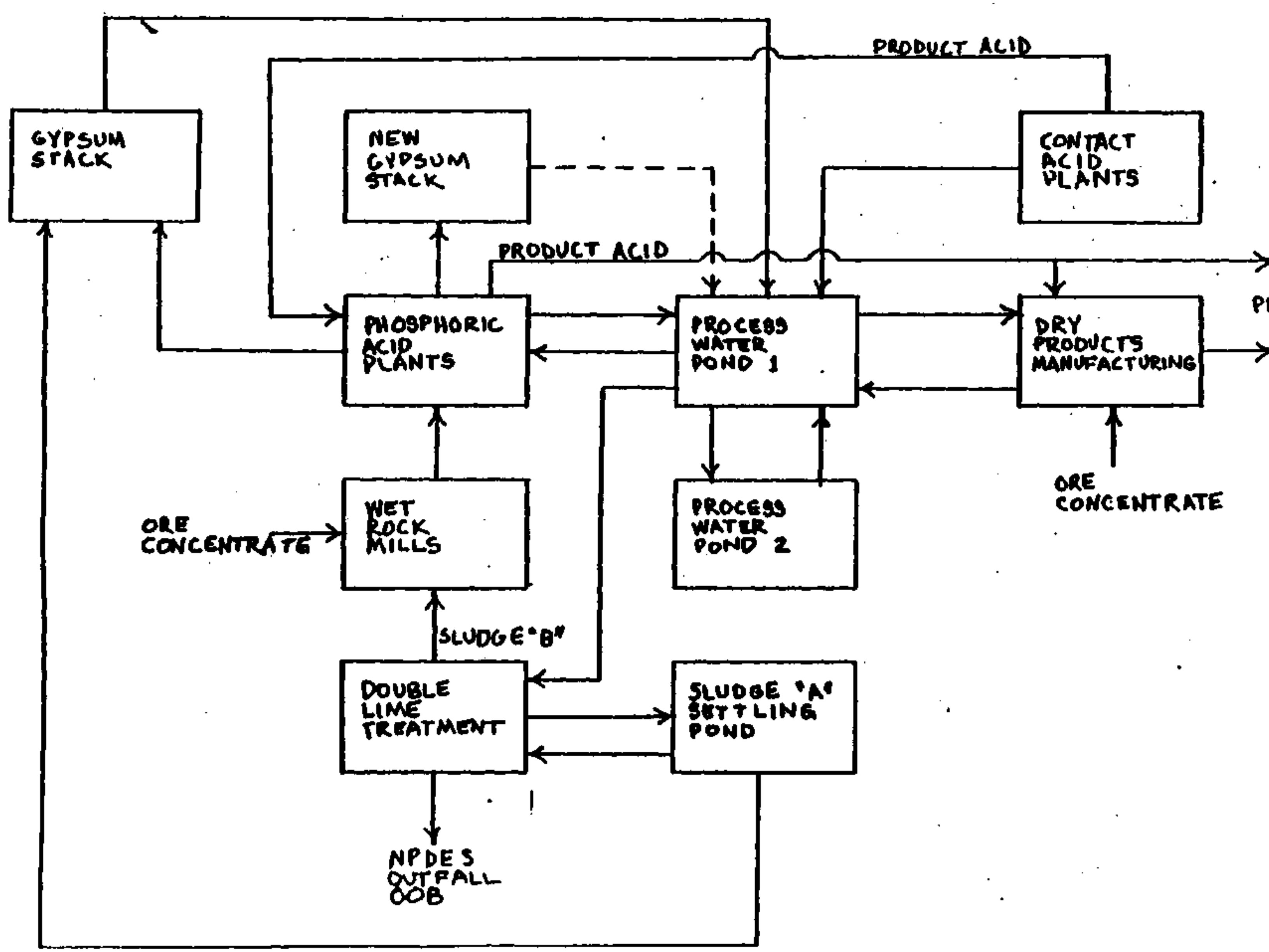


EXHIBIT 2
Process Flow Diagram for Gardinier

APPENDIX A5--TRIP REPORT

AGRICO/UNCLE SAM, LA

elemental form and converted to sulfuric acid in a co-located sulfuric acid plant. Power is generated using the steam from this sulfuric acid operation; the plant is, in fact, a net producer of electricity.

The wet phosphate rock (about 10 to 12 percent water), after being stockpiled on site, is fed into a ball mill and ground with iron balls. River water and/or treated (single-limed) process water, depending on water balance needs, is an input necessary for the mill operation. The pond water is too low in pH to be used directly; it is therefore, single limed to a pH of 2.7 to 3.0. When diluted with river water and the rock, mill material is held at a pH of 4.0 to 4.5. The resultant slurry (67 percent solids), from which course materials have been separated and returned to the mill, is routed to one of two attack and filtration trains.

In the attack tank, acid is added to the rock to acidulate the phosphate; this acid is made up primarily of concentrated (93 percent) sulfuric acid but includes recycle acid from the filtration/gyp-wash operation, some process sulfuric acid from the silicon tetrafluoride operation (discussed below), and battery acid (less than 1 percent of the total acid feed). Heat released during the acidulation step is controlled by routing hot slurry to a flash cooler from which water vapor and, therefore, heat is removed from the slurry that is then returned, to the attack tank. The flash-cooler water vapors, which contain fluorides, are condensed in a barometric condenser using river water as the contact cooling water. This contact cooling water, the condensed water vapor, and any entrained fluorides and phosphates (from boilover) are disposed, untreated, via a sump/ditch to an NPDES outfall. Fume scrubbers used to clean fumes from the attack tank are also flushed with river water and discharged via the same system.

The acidulated slurry of phosphoric acid and gypsum crystals that leaves the attack tank is routed to the filter operation. Both filters (one with each train) are 30C tilting pan filters. The product acid is removed at the first vacuum step. Next, active pond water (pumped from the 04 basin, discussed below) and some minor quantity of process wastewater (crud circuit wash water) from the uranium recovery operation (discussed below) is used to wash the crystals in a two-step counter-current wash/filter operation. The wash water is first applied to the crystal at the last wash (i.e., last step before tilting the pan and removing the crystal), this wash liquor is vacuumed off and then used a second time for the first wash. The liquor vacuumed off after this first wash has therefore been used twice to wash the gypsum and is relatively high in acid; this liquor, referred to as recycle acid, is returned to the attack tank with the other acids discussed above.

The vacuum filter operation produces fumes that must be collected and scrubbed; the scrubber water is discharged, untreated, via the NPDES outfall.

The gypsum is washed from the inverted filter pans, dropped to a gypsum sump, and slurried with active pond water taken from the 04 basin. In addition, process wastewater (crud circuit caustic water) and solids waste (turnaround solids) from the uranium recovery plant are routed to the gypsum

TRIP REPORT

Agrico (Freeport) Uncle Sam
Uncle Sam, Louisiana

September 25-26, 1990

Introduction

EPA is currently preparing a regulatory determination that will establish whether or not regulation of any of the wastes covered by the July 31, 1990, Report to Congress on Special Wastes from Mineral Processing is warranted under subtitle C of RCRA. The Agency, in order to better make this decision, is undertaking the task of further data collection and analysis of the generation and management of process wastewater and phosphogypsum from phosphoric acid operations. Collection of additional data is being accomplished in part through visits by EPA and Agency representatives to selected phosphoric acid facilities representing three major areas of phosphoric acid production. The purpose of the visits was primarily to gain a better understanding of the flow of water into and out of various sub-operations within the phosphoric acid facility. Pre-trip knowledge of process wastewater flows at phosphoric acid plants was confined to the total flow of water from the plant to the various waste management operations such as cooling ponds and gypsum stacks. This visit was part of an effort by the Agency to better understand what individual streams generated within the plant make up the total flow from the plant to the management units. While waste management operations were discussed and visited, gathering additional insight into their operations was of secondary importance.

The site visit to the Agrico Uncle Same was conducted on September 25-26, 1990; the facility is located in Uncle Sam, Louisiana. The meetings consisted of representatives from Agrico, Freeport (Agrico's parent company), EPA (headquarters office), and EPA consultants: ICF, Inc., Badger Design and Constructors, and SAIC; a list of the participants follows this report. The visit took the form of a lengthy meeting the afternoon of the 25th, during which processes and process wastewater flows were discussed; a tour of the phosphoric acid plant and associated operations the morning of the 26th; and a final meeting during that afternoon. The information gathered during those meetings and the tour are the topic of the remainder of this report. The report first discusses the plant production operations, second highlights the waste management practices, and third presents, in attached exhibits, flow charts of production and waste management and other pertinent information.

Overview of Plant Production Operations

The facility is located in Uncle Sam, Louisiana and is a primary mineral processor, producing phosphoric acid, uranium oxide, silicon tetrafluoride and fluosilicic acid. The primary feed for this mineral processing operation is concentrated phosphate rock barged from Agrico's Florida mine operations. Sulfur is the other major feedstock necessary for the production of phosphoric acid and silicon tetrafluoride; this is transported to the facility in its

small quantity of fluorides, is routed to barometric condensers as is the vapor from the two 33 percent evaporators which use no Swift towers. The eight barometric condensers use river water as the contact cooling water. This contact cooling water, the condensed water vapor, and any entrained fluorides are routed, untreated, via a sump/ditch to an NPDES outfall.

The fluosilicic acid from the four Swift towers that collect and use the acid is either sold as fluosilicic acid or processed in an on-site plant to produce silicon tetrafluoride. The silicon tetrafluoride process flashes off SiF_4 which is dried in a tower using sulfuric acid; the dried gas is compressed and put in pressure tanks for transport.

Highlights of Waste Management Practices

Once-through cooling water system--As discussed above, Uncle Sam uses a once through contact cooling water system to condense vapors in the barometric condensers attached to both the flash coolers and all eight evaporators. Scrubber water from the attack tank and vacuum filter fume scrubbers is also discharged in this manner. In addition, the inactive stack pond water is collected separately from the active stack water and discharged when not required for production operations.

Phosphogypsum disposal stacks--The stack operation is typical of most phosphoric acid operations, however, the height is limited to approximately 100 feet. Parts of the stack are deemed inactive by the virtue of not currently being used to dispose gypsum; the active sections of the stack are currently receiving gypsum or are not receiving gypsum but have not been fully decanted to remove standing water. It is important to note that this inactive/active delineation is for NPDES purposes; inactive sections are not permanently closed and may be reopened at a later date. Another note is that materials in addition to gypsum are disposed in the stack, though in relatively small portions; these materials include CaF_2 from the lime treatment plant, filter cloths, and other solids from scrubber and tank cleanouts. In addition to the currently operated stack, Agrico is currently planning and constructing a new stack beside the old stack.

Stack water management--Water from the currently inactive portion of the stack is diverted to an inactive stack pond. Water from this pond is either reused, on an as needed basis, or discharged, untreated, via the NPDES outfall. The water from the currently active portion of the stack is collected via a toe ditch and routed to a lift station that pumps the water to a return ditch in which the water flows by gravity to back to the plant. This unlined ditch routes the water to a small holding impoundment referred to as the 04 Basin. Water from this basin is pumped for use in the plant, as discussed in the previous section. In addition to the return water that is routed from the stack to this basin, 5 percent sulfuric acid and cleanout solids are routed to this impoundment roughly on a weekly basis. This co-managed acid is then taken in with the active stack return water for use in filtering and slurrying the gypsum (i.e., the sulfuric acid placed in the

sump and mixed with the gypsum. The entire waste slurry is piped to the gypsum stack (discussed below) for disposal.

The phosphoric acid vacuumed from the gypsum in the filter operation is routed to an on-site uranium recovery plant; uranium (yellowcake) is produced from this operation. The design rate for uranium oxide (U_3O_8) at the Uncle Sam plant is 690,000 pounds annually. The company pointed out that uranium recovery has no effect on quality of the final phosphoric acid product; although the product obviously has reduced uranium content. The plant uses two circuits, a primary circuit to remove and concentrate the uranium from the large volume of phosphoric acid and a second circuit to recover the final uranium product, yellowcake. The feed acid is pre-treated before entering the first circuit; impurities are removed and the uranium is oxidized to the +6 oxidation state. A countercurrent solvent extraction is used to remove the uranium from the oxidized acid. The solvent is a "high-flash hydrocarbon diluent" containing two phosphine base compounds (D2EHPA and TOPO). The uranium is stripped from the pregnant solvent using a closed loop of "treated" phosphoric acid. The pregnant "strip" acid goes to the second circuit for a solvent extraction operation nearly identical to the first using the same solvent and again after oxidizing the "strip" acid. The uranium, in this second circuit, is stripped from the pregnant solvent using ammonium carbonate solution. This uranium-rich ammonium carbonate solution is stripped using steam to remove the ammonia and carbon dioxide and causing the uranium to precipitate. The resulting precipitate is thickened, dried, calcined, sized, and drummed for delivery.

After passing through the first circuit of the uranium removal operation, the product acid (combined output from both attack/filtration trains) is routed to the evaporators to concentrate the acid. The entire evaporation operation consists of four progressive evaporative stages. All product acid is first concentrated to 33 percent in one of two evaporators, then to 40 percent in one of three evaporators. The 40 percent acid is clarified in a centrifuge to remove solids. The clarified 40 percent acid is concentrated to 48 percent acid in one of two evaporators, then to 54 percent acid in one evaporator. The 54 percent acid is shipped either to Agrico's Taft or Donaldsonville (both in Louisiana) fertilizer production facilities; transport is via the Mississippi River on specialized barges.

Fluorides recovery units, known as Swift towers, are paired up with six of the eight evaporators (all but the first two that concentrate the acid to 33 percent). These Swift towers strip fluorides from the water vapor driven off during the evaporation operation. The stripping medium used in four of the six towers, those paired with the 48 and 54 percent evaporators and one of the three 40 percent evaporators, is clarified river water. This water is sprayed under pressure through the vapors, stripping out HF and SiF_4 which when cooled in an aqueous environment combine to form fluosilicic acid (H_2SiF_6). The remaining two Swift towers use active pond water from the 04 Basin as the stripping medium; the strip solution, water and fluorides (also predominantly in the form of H_2SiF_6), are routed to the 04 Basin to be mixed with pond water and reused in the attack/filtration operation. The remaining vapor from the Swift towers, which, although stripped, still contains some

EXHIBIT 1
List of Attendees -- Uncle Sam, September 18, 1990

	Organization	Phone Number
Rusty Walker	Freeport	(504) 582-4232
George Chambers	Freeport	(504) 582-4259
Bob Dennis	Agrico	(504) 562-3501
Bob Sharshan	Agrico	(504) 562-3501
John Wen	Agrico	(504) 562-3501
Susan Stewart	Agrico	(504) 493-5904
Bob Hall	EPA	(703) 308-8412
Scott Ellinger	EPA	(703) 308-8410
Frank Smith	EPA	(202) 382-2791
David Bauer	ICF Incorporated	(703) 934-3697
Rich Pierce	ICF Incorporated	(703) 934-3554
Ron Rimelman	SAIC	(703) 821-4861
John Martinez	Badger Design and Constructors, Inc.	(813) 289-1991

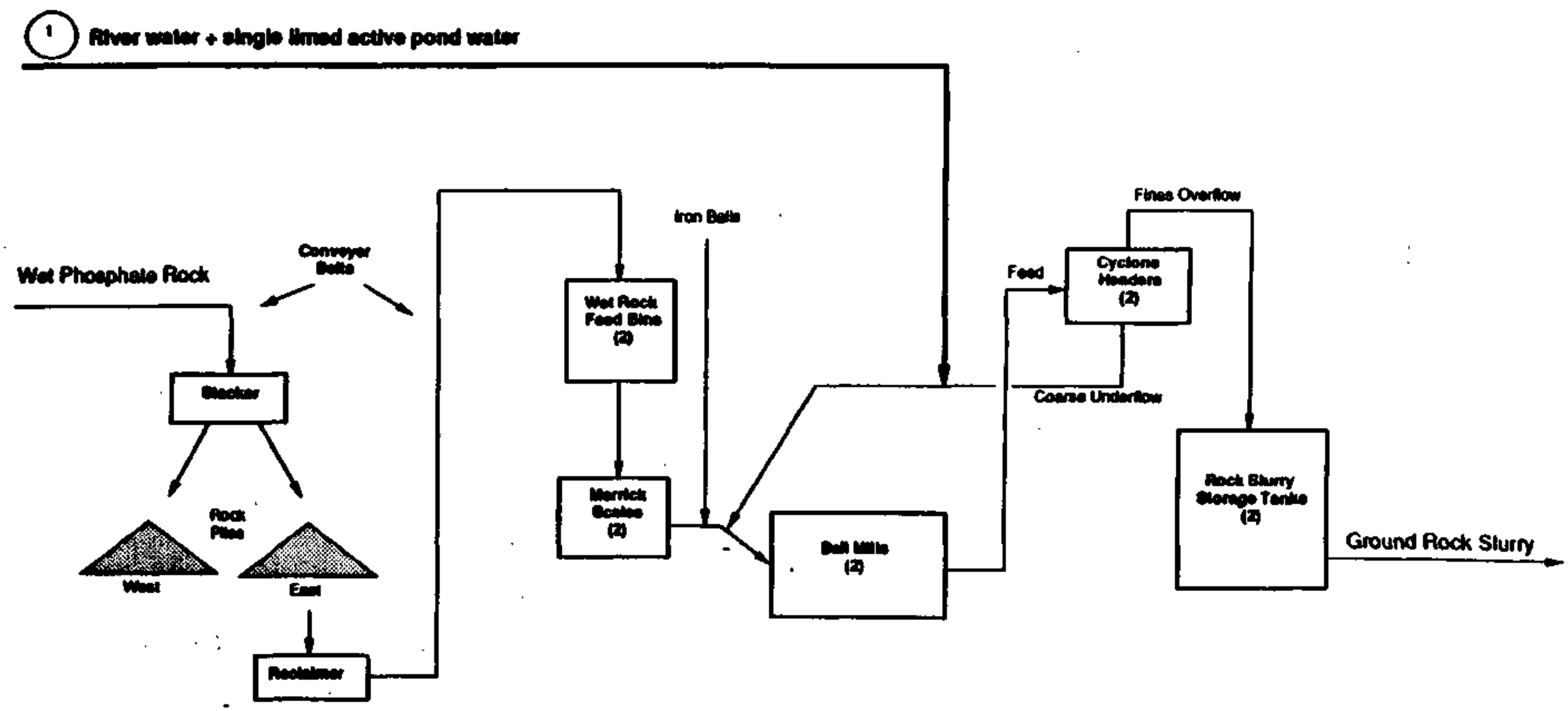
Basin does not go entirely or even in majority to the attack vessel for acidulation, much of it goes to the stack as slurry water/acid).

Liming operation--Uncle Sam has a lime treatment plant installed to meet permit requirements in case they ever need to discharge gypsum transport water and run off from their active stack under their NPDES permit. The plant has never been used to treat water for discharge. Currently the plant is used for single-stage lime treatment of return water to be used in the ball mill. Bob Dennis indicated that a simple plumbing change would convert the system back to double liming if need for discharge. He also indicated that the only time this would be used was if the company shut down. The treatment solids, impure CaF_2, is disposed in the gypsum stack.

Water Streams

Other Streams

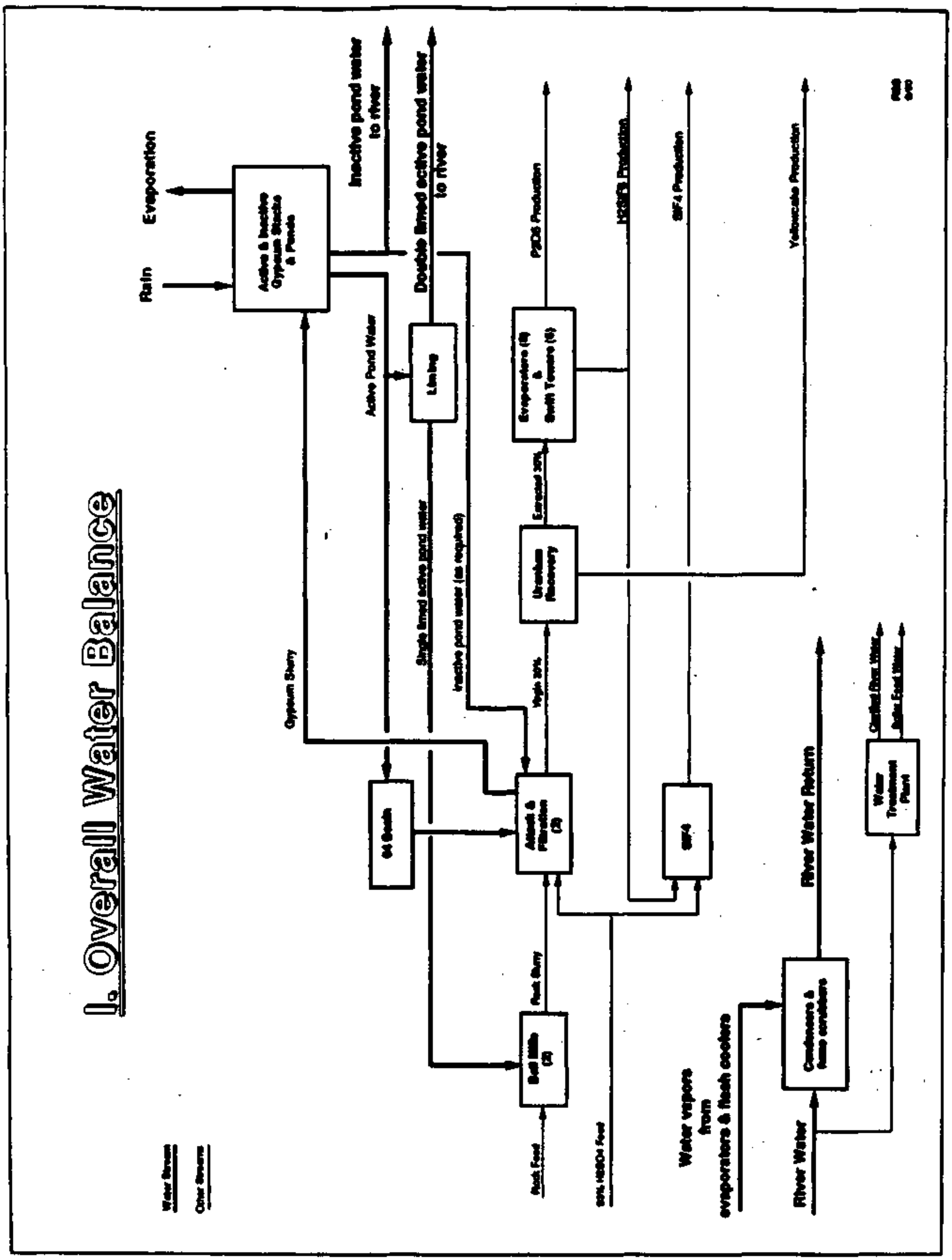
II. Ball Mills



RSS 9/90

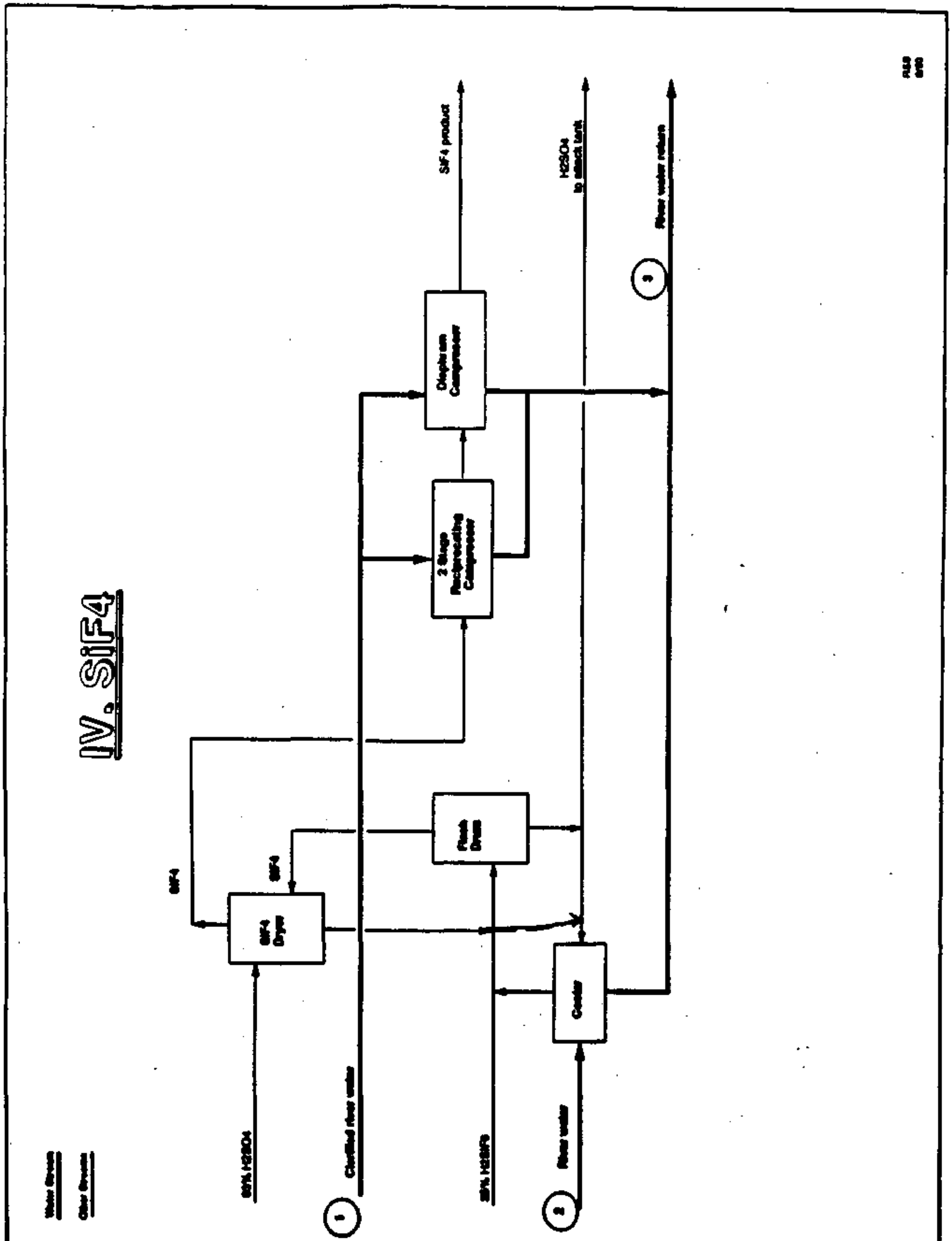
EXHIBIT 2

BLOCK FLOW DIAGRAMS FOR AGRICO/UNCLE SAM



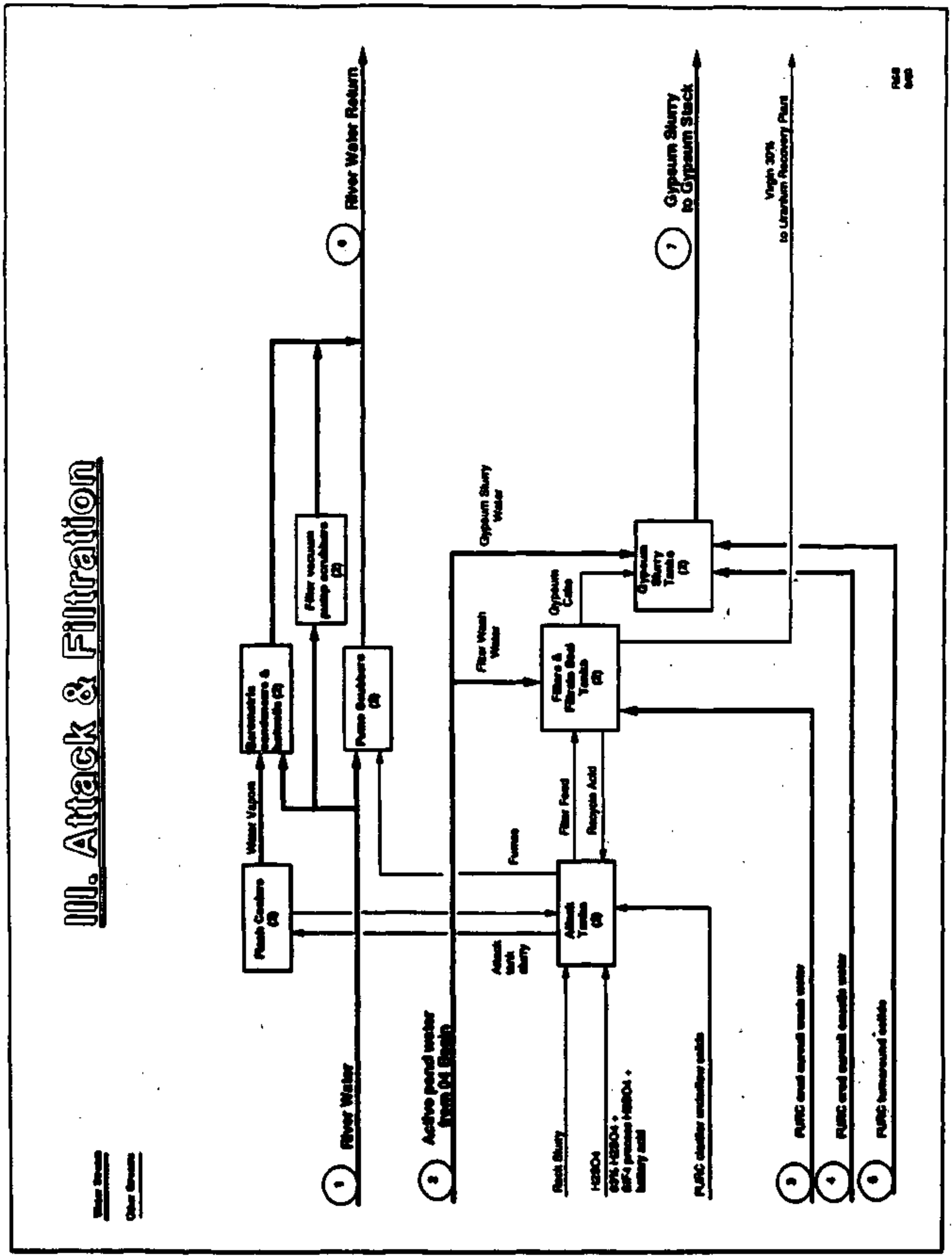
P.24

A5-10


IV. SiF4
Water Stream
Other Stream
93% H2SO4
Clarified river water
25% H2SiF6
River water
SiF4 Dryer
SiF4
SiF4
Flash Drum
Cooler
2 Stage Reciprocating Compressor
Diaphragm Compressor
SiF4 product
H2SO4 to attack tank
River water return

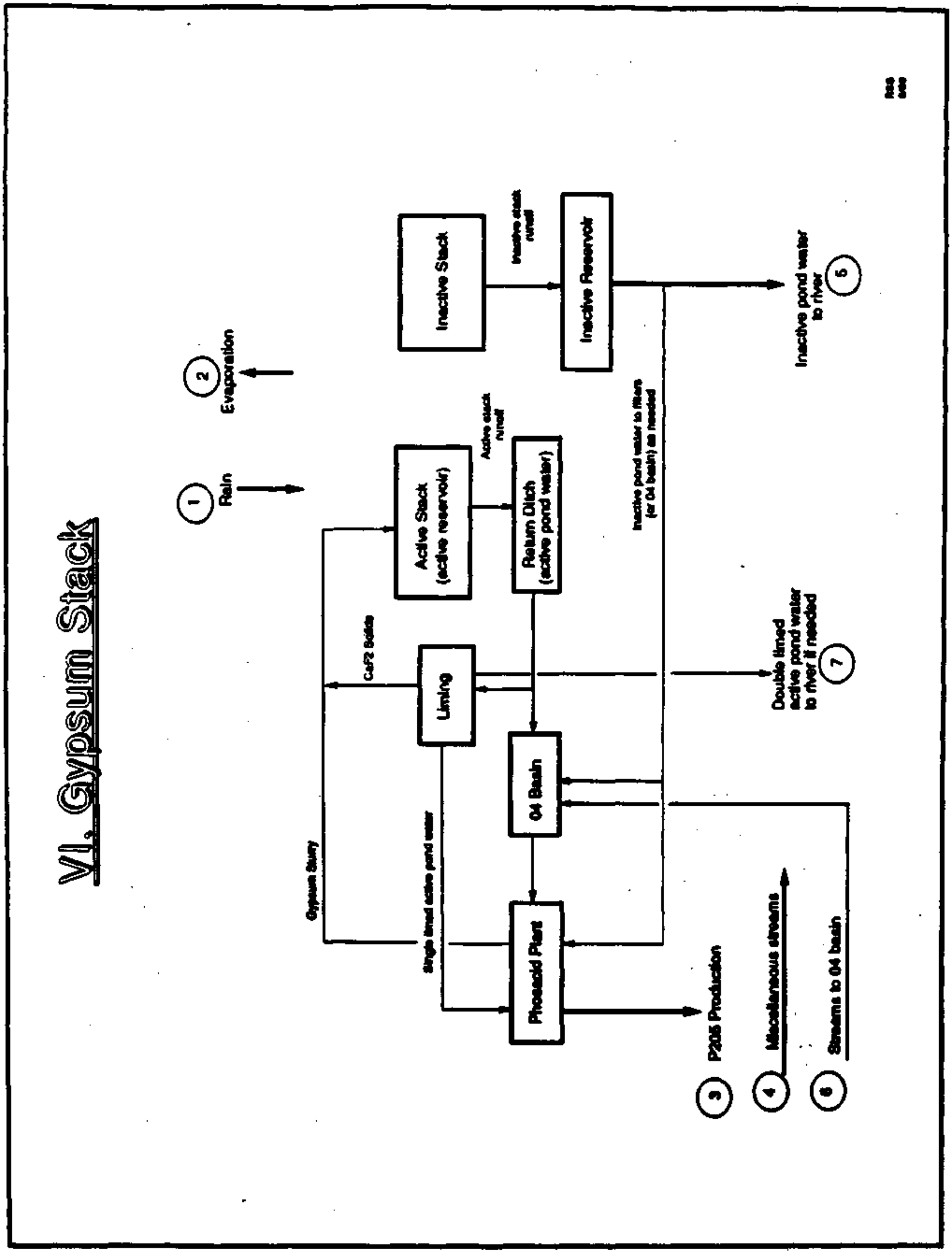
P.25

A5-9


III. Attack & Filtration
River Water Return
Gypsum Slurry
to Gypsum Stack
River Water
Active pond water
from 04 Basin
Water Vapor
Gypsum Slurry
Water
Filter Wash
Water
Gypsum
Cake
Filter Feed
Recycle Acid
Fumes

P.26

A5-12


VI. Gypsum Stack
1 Rain
2 Evaporation
Inactive Stack
Inactive stack runoff
Inactive Reservoir
Inactive pond water to river
5
Active Stack (active reservoir)
Active stack runoff
Return Ditch (active pond water)
Inactive pond water to filters (or 04 basin) as needed
CaF2 Solids
Liming
Double limed active pond water to river if needed
7
04 Basin
Gypsum Slurry
Single limed active pond water
Phosacid Plant
3 P205 Production
4 Miscellaneous streams
6 Streams to 04 basin

A5-11

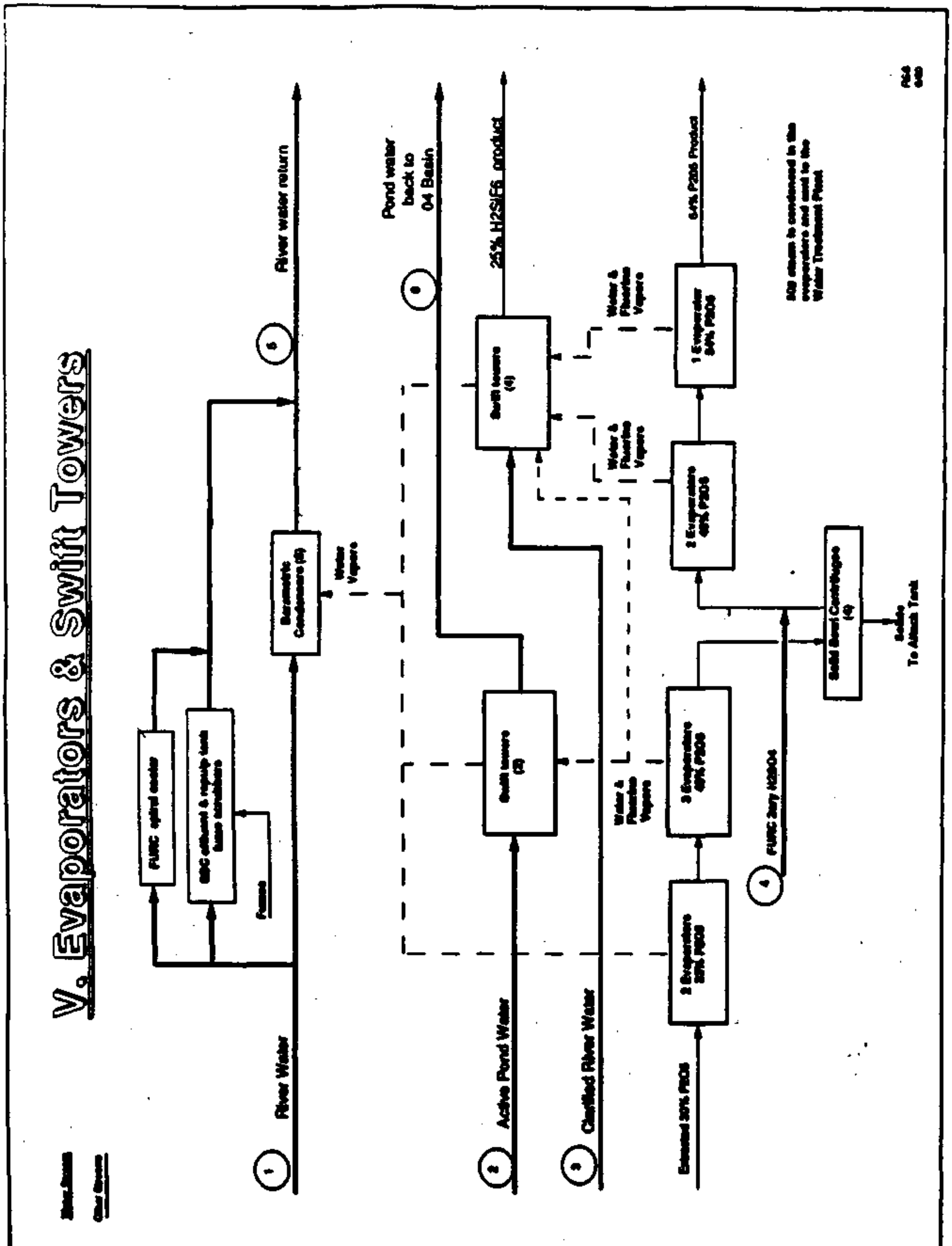

V. Evaporators & Swift Towers
FURC spiral cooler
Fumes
1
River Water
Barometric Condensers (8)
Water Vapors
5
River water return
Pond water back to 04 Basin
6
2
Active Pond Water
Swift towers (2)
Swift towers (4)
25% H2SiF6 product
3
Clarified River Water
Water & Fluorine Vapors
Water & Fluorine Vapors
Water & Fluorine Vapors
Extracted 30% P2O5
1 Evaporator 54% P2O5
64% P205 Product
4
FURC 3ary H2SO4
Solid Bowl Centrifuges (4)
Solids
To Attack Tank

EXHIBIT 4

WATER FLOW DATA FOR AGRICO/UNCLE SAM

650,000 TPY P2O5

60 inches/year rain

#	gpm II. Ball Mills
1	491 Total water
1a	261 River water
1b	230 Single limed active pond water

#	gpm III. Attack & Filtration
1	13,520 River water
1a	7,400 to flash cooler barometric condensers
1b	2,120 to filter vacuum scrubbers
1c	4,000 to attack tank fume scrubbers
2	4,000 Active pond water
2a	1,800 filter wash water (inactve pond water when needed)
2b	2,200 gypsum slurry water
3	11 FURC crud curcuit wash water
4	11 FURC crud curcuit caustic wash
5	1 FURC turnaround solids
6	13,810 River water return
6a	7,690 from flash cooler barometric condensers
6b	2,120 from filter vacuum scrubbers
6c	4,000 from attack tank fume scrubbers
7	3,200 Gypsum slurry to gypsum stack

#	gpm IV. SiF4
1	54 Clarified river water
1a	18 to recipricating compressor
1b	36 to diaphram compressor
2	360 River water to cooler
3	414 River water return

#	gpm V. Evaporators & Swift towers
1	32,155 River water to barometric condensers
1a	32,000 to evaporator barometric condensers
1b	85 to FURC spiral cooler
1c	70 to SBC effluent & repulp tank scrubbers
2	400 Active pond water to #1&2 Swift towers
3	20 Clarified river water #3,4,5&6 Swift towers
4	5 FURC secondary H2SO4
5	32,955 River water return
6	410 Dilute H2SiF6 from #1&2 Swift towers to 04 basin

A5-13

EXHIBIT 3
RAIN DATA FOR AGRICO/UNCLE SAM

RainData

Month	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	77-89
Jan	5.2	10.6	4.8	5.4	2.1	3.3	6.9	5.1	5.8	2.6	6.5	3.3	2.7	4.7	6.0
Feb	1.7	1.8	11.4	.8	8.2	7.7	8.4	5.4	8.6	2.8	6.9	10.6	.4	4.1	5.7
Mar	3.3	2.8	3.2	14.3	2.9	3.1	7.0	2.9	5.1	1.9	4.0	8.3	2.0	14.5	4.7
Apr	7.8	3.9	15.5	14.1	2.3	6.0	10.2	.7	3.2	1.7	1.3	7.3	2.4	5.3	5.9
May	1.8	9.1	5.2	7.6	3.1	.6	2.9	3.0	1.6	1.0	8.3	.9	4.5	4.3	3.8
Jun	1.8	6.6	1.3	2.2	6.5	4.6	8.2	7.4	.9	6.8	9.5	3.7	10.0	1.2	5.3
Jul	2.8	8.6	10.8	5.9	5.7	6.5	5.5	10.5	8.8	5.3	3.7	7.9	11.7	2.7	7.2
Aug	21.4	6.1	4.1	3.5	2.9	5.8	5.4	6.9	8.0	6.0	3.6	5.3	1.8	1.8	6.2
Sep	8.6	3.6	4.6	6.7	3.3	3.3	3.0	3.1	6.4	2.0	1.8	8.4	3.0		4.4
Oct	4.2		2.3	3.5	1.0	5.8	2.5	7.4	11.8	3.2	1.1	6.9	1.1		3.9
Nov	5.8	6.0	3.8	5.3	2.7	6.1	2.2	2.3	.2	6.0	5.1	1.4	12.4		4.6
Dec	1.8	2.4	2.7	2.1	4.8	9.8	4.9	5.1	7.9	6.7	2.1	3.7	6.2		4.6
Total	66.2	61.6	69.7	71.4	45.5	62.6	67.1	59.8	68.3	46.2	53.9	67.7	58.2	38.6	61.4

EXHIBIT 4 (continued)

WATER FLOW DATA FOR AGRICO/UNCLE SAM

#	gpm VI. Gypsum stack
1	2,548 Rain (820 acres)
2	-382 Evaporation
3	-1,835 P2O5 Production
3a	680 water in rock slurry
3b	80 water in 93% H2SO4
3c	-291 flash cooler water vapors
3d	-392 hydration water for gypsum
3e	-832 gypsum stack moisture
3f	-850 30% acid
3g	-230 single limed active pond water to ball mills
4	200 Miscellaneous streams such as pump seal water, washdowns ect
5	531 Inactive pond water to the river
6	501 Streams to 04 basin
6a	3 FURC API separator
6b	16 FURC storm runoff
6c	62 plant storm runoff
6d	10 boilout solution
6e	410 weak H2SiF56 from #1&2 Swift towers
7	0 Double limed active pond water to river

APPENDIX A6–TRIP REPORT

AGRICO/DONALDSONVILLE, LA

to the facility in its elemental form and converted to sulfuric acid in a co-located sulfuric acid plant. This plant does not produce its own power but utilizes the steam generated in its sulfuric acid plant in other on-site operations.

The wet phosphate rock (about 10 to 12 percent water), after being stockpiled on site, is fed into a ball mill and ground with iron balls. Clarified river water, lime treated cooling pond water, and/or lime treated seepage ditch water, depending on water balance needs, are used in the milling operation. The pond water is too low in pH to be used directly; it is, therefore, single limed to a pH around 3.0. The resultant slurry is routed to one attack and filtration train.

In the attack tank, acid is added to the rock to acidulate the phosphate; this acid is made up primarily of concentrated (93 percent) sulfuric acid but includes recycle acid from the filtration/gypsum wash operation. Heat released during the acidulation step is controlled by routing hot slurry to a flash cooler from which water vapor and, therefore, heat is removed from the slurry that is then returned, cooled, to the attack tank. The flash-cooler water vapors, which contain fluorides, are condensed in a barometric condenser using water from the cooling pond (approximately 2,000 gpm) as the contact cooling water. This contact cooling water, the condensed water vapor, and any entrained fluorides and phosphates (from upsets) are used as plant wash water to wash pipe systems (approximately 1,000 gpm), are used to wash the gypsum on the filter (approximately 1,000 to 1,200 gpm), or are routed via the granulation pond to the cooling pond (approximately 1,000 gpm). Fume scrubbers used to clean fumes from the attack tank are also flushed with water from the cooling pond (approximately 2-3,000 gpm) and discharged to the cooling pond.

The slurry of phosphoric acid and gypsum crystals that leaves the attack tank is routed to the filter operation. The product acid is removed at the first vacuum step. Water from the cooling pond (along with some minor quantity of process wastewater from the uranium recovery operation when it is operational) is used to wash the crystals in a two-step counter-current wash/filter operation. The wash water is first applied to the crystal at the last wash (i.e., last step before tilting the pan and removing the crystal); this wash liquor is vacuumed off and then used a second time for the first wash. The liquor vacuumed off after this first wash has, therefore, been used twice to wash the gypsum and is relatively high in acid; this liquor, referred to as recycle acid, is returned to the attack tank with the sulfuric acid as discussed above.

Non-contact cooling water used as vacuum pump water is used on a once-through basis and is discharged to an NPDES outfall. The vacuum filter operation produces fumes that must be collected and scrubbed; the scrubber water is discharged to the cooling pond.

The gypsum is washed from the inverted filter pans, dropped to a gypsum sump, and slurried with pond water taken from the cooling pond. Miscellaneous plant water (e.g., sump water, plant washdown water) and waste water treatment

TRIP REPORT

Agrico (Freeport) Faustina Plant
Donaldsonville, Louisiana

September 27, 1990

Introduction

EPA is currently preparing a regulatory determination that will establish whether or not regulation of any of the wastes covered by the July 31, 1990, Report to Congress on Special Wastes from Mineral Processing is warranted under subtitle C of RCRA. The Agency, in order to better make this decision, is undertaking the task of further data collection and analysis of the generation and management of process wastewater and phosphogypsum from phosphoric acid operations. Collection of additional data is being accomplished in part through visits by EPA and Agency representatives to selected phosphoric acid facilities representing three major areas of phosphoric acid production. The purpose of the visits was primarily to gain a better understanding of the flow of water into and out of various sub-operations within the phosphoric acid facility. Pre-trip knowledge of process wastewater flows at phosphoric acid plants was confined to the total flow of water from the plant to the various waste management operations such as cooling ponds and gypsum stacks. This visit was part of an effort by the Agency to better understand what individual streams generated within the plant make up the total flow from the plant to the management units. While waste management operations were discussed and visited, gathering additional insight into their operations was of secondary importance.

The site visit to the Agrico Faustina plant was conducted on September 27, 1990; the facility is located in Donaldsonville, Louisiana. The meetings consisted of representatives from Agrico, Freeport (Agrico's parent company), EPA (headquarters office), and EPA consultants: ICF, Inc., Badger Design and Constructors, and SAIC; a list of the participants follows this report. The visit took the form of a lengthy meeting the morning of the 27th, during which processes and process wastewater flows were discussed, and an afternoon tour of the phosphoric acid plant and associated operations. The information gathered during the meeting and tour are the topic of the remainder of this report. The report first discusses the plant production operations, second highlights the waste management practices, and third presents, in attached exhibits, flow charts of production and waste management and other pertinent information.

Overview of Plant Production Operations

The facility is located in Donaldsonville, Louisiana and is a primary mineral processor, producing phosphoric acid and fluosilicic acid. There is a uranium recovery plant on site; however, it is not currently operational. The primary feed for this mineral processing operation is concentrated phosphate rock barged from Agrico's Florida mine operations. Sulfur is the other major feedstock necessary for the production of phosphoric acid; this is transported

sludge (e.g., calcium fluoride) are also routed to the gypsum sump to be mixed with into the slurry. (When its operational, some wastes from the uranium recovery plant are also routed to the gypsum sump.) The gypsum slurry is piped to the gypsum stack (discussed below) for disposal.

Product acid is (combined output from both attack/filtration trains) is routed from the A and B settlers to the evaporators to concentrate the acid. The entire evaporation operation consists of three progressive evaporative stages. All product acid is first concentrated to 35 percent in one of two evaporators. The acid is then clarified in a centrifuge to remove solids. The clarified acid is concentrated to 42 percent acid in one evaporator, then to 48 percent acid in a second evaporator. Fluoride recovery units, known as Swift towers, are paired up with two of the four evaporators (all but the first two that concentrate the acid to 35 percent).

These Swift towers strip fluorides from the water vapor driven off during the evaporation operation. The stripping medium used in the towers is clarified river water; the resulting liquid is fluosilicic acid. The remaining vapor from the Swift towers, which, although stripped, still contains some fluorides, is routed to barometric condensers as is the vapor from the two 35 percent evaporators that are not equipped with Swift towers. The four barometric condensers use cooling pond water as the contact cooling water. This contact cooling water, the condensed water vapor, and any entrained fluorides are routed to the cooling pond. The fluosilicic acid from the Swift tower is processed and sold.

Highlights of Waste Management Practices

Phosphogypsum disposal stacks--The stack operation is typical of most phosphoric acid operations, except that the stack height is limited to approximately 100 feet. Materials in addition to gypsum (e.g., CaF_2 from the lime treatment plant, filter cloths, and other solids from scrubber and tank cleanouts) also are disposed in the stack. Water from the active stack operation is routed to the cooling pond for reuse in the plant, as is water collected from the inactive stack at the facility.

Cooling Pond--A 97 acre cooling pond is used to manage virtually all wastewater generated at the plant. An earthen dike splits the pond into U-shaped unit. This configuration is used so that wastewaters can be discharged into the pond at one end of the "U" and pumped from the pond (and returned to the plant) from the opposite end of the "U", thereby maximizing residence time in, and heat loss from, the pond. On the day of the visit, however, the dike was open between the discharge and return pipes. The plant manager indicated that the dike had been opened because at this time of year the water needed little residence time in the pond in order to be cool enough to reuse in the plant. The pond, therefore, appears to be used part of the year for surge capacity and storage rather than for cooling. The water streams flowing into the pond are cooling water from the barometric condensers (approximately 54,000 gpm) water from the fume scrubbers (approximately 2,000 gpm), decant from the stack (approximately 4,900 gpm), active rainfall (approximately 971 gpm on average from a 300 acre area), pond water from inactive stacks,

evaporator boilout, line wash water, spills and leaks in the plant, and water from the fluorides plant. Water leaves the pond as recycle water (approximately 60,000 gpm), evaporation (952 gpm) and seepage (11 gpm).

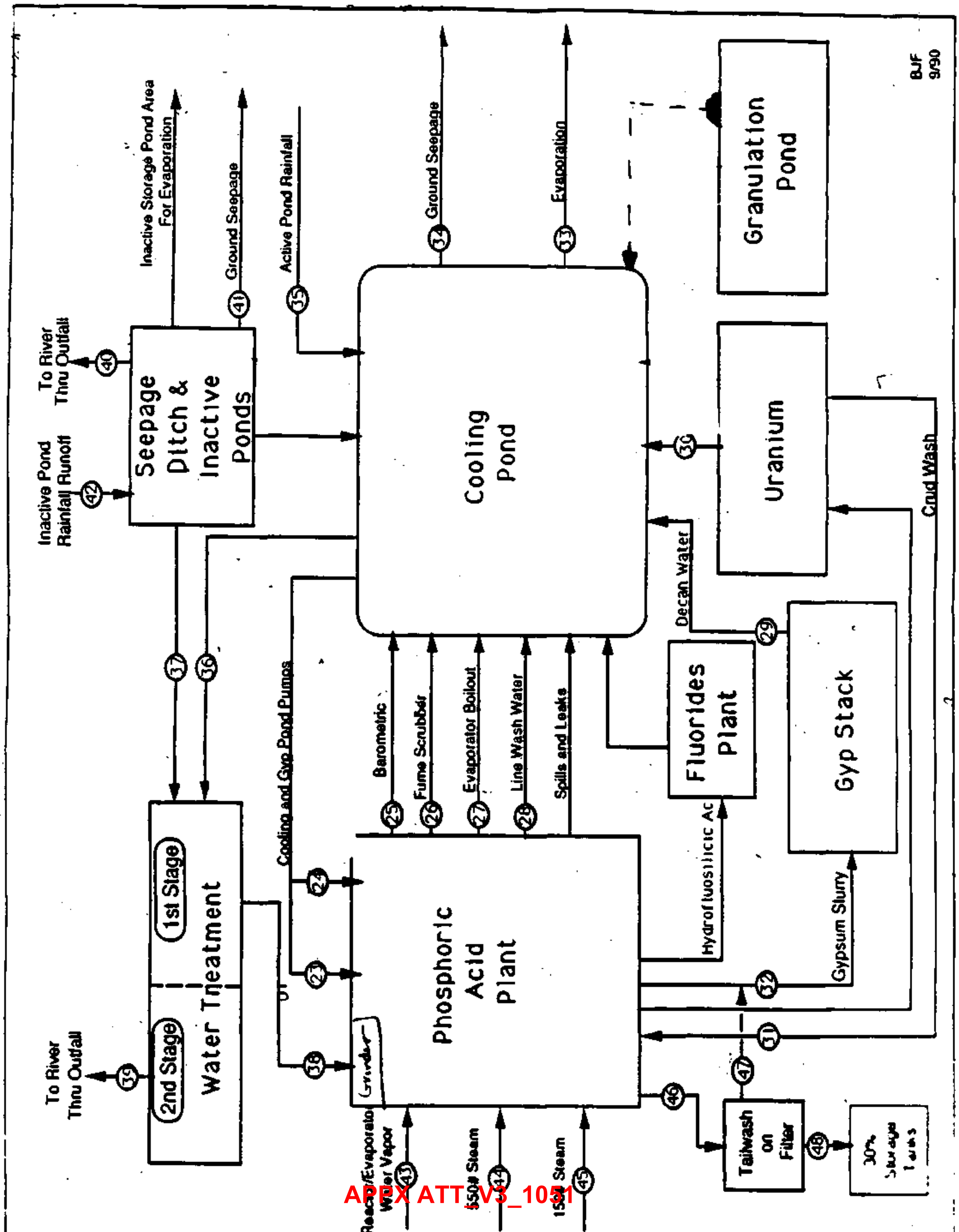
Liming operation--The Donaldsonville plant has a lime treatment plant installed to meet permit requirements in case they ever need to discharge transport (stack) water under their NPDES permit. The plant has never been used to treat water for discharge. Currently the plant is used for single-lime treatment of water that is used in the ball mill. The treatment solids, impure CaF_2, is disposed in the gypsum stack via the gypsum slurry sump.

A6-5

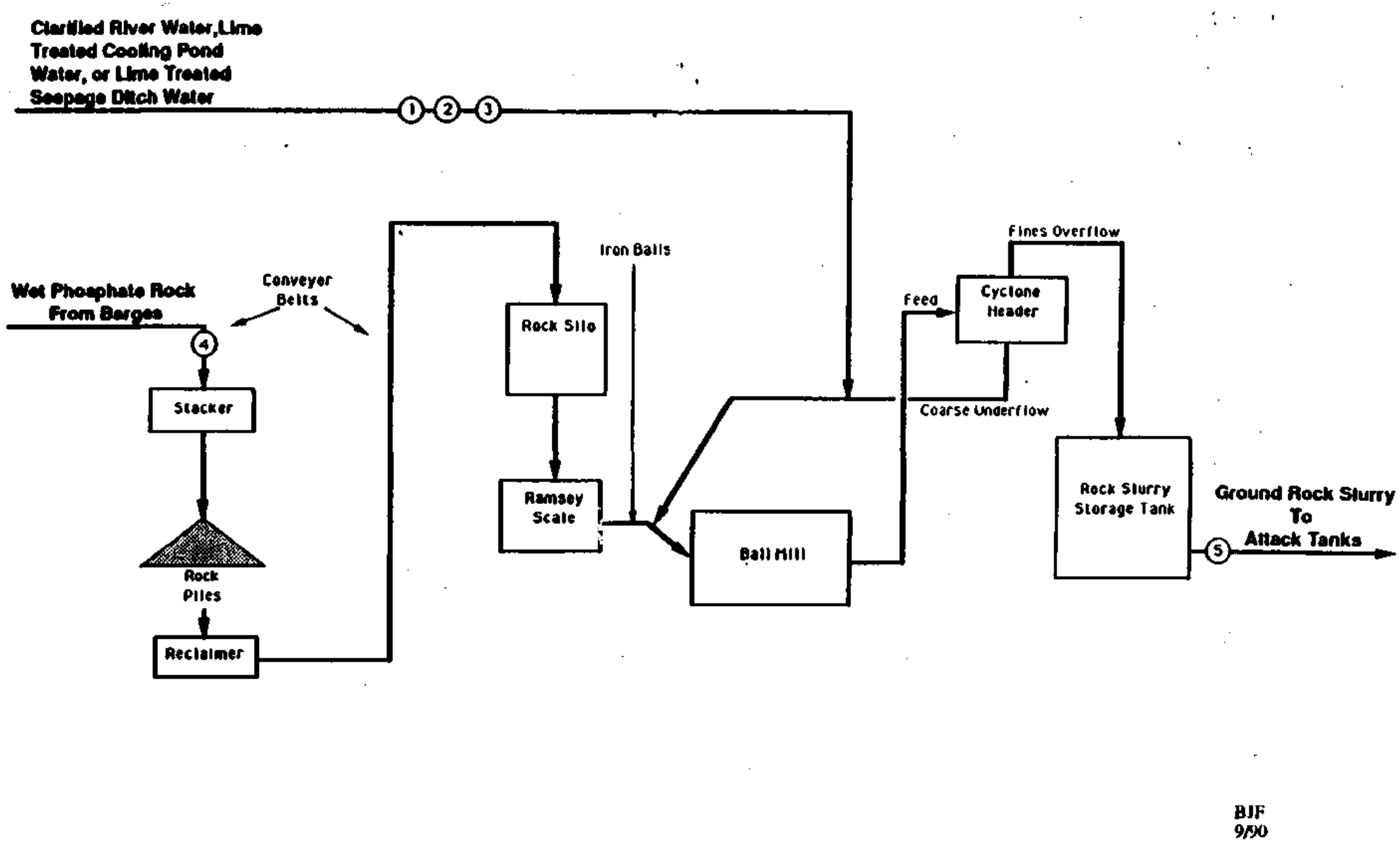
EXHIBIT 1
List of Attendees -- Donaldsonville, September 18, 1990

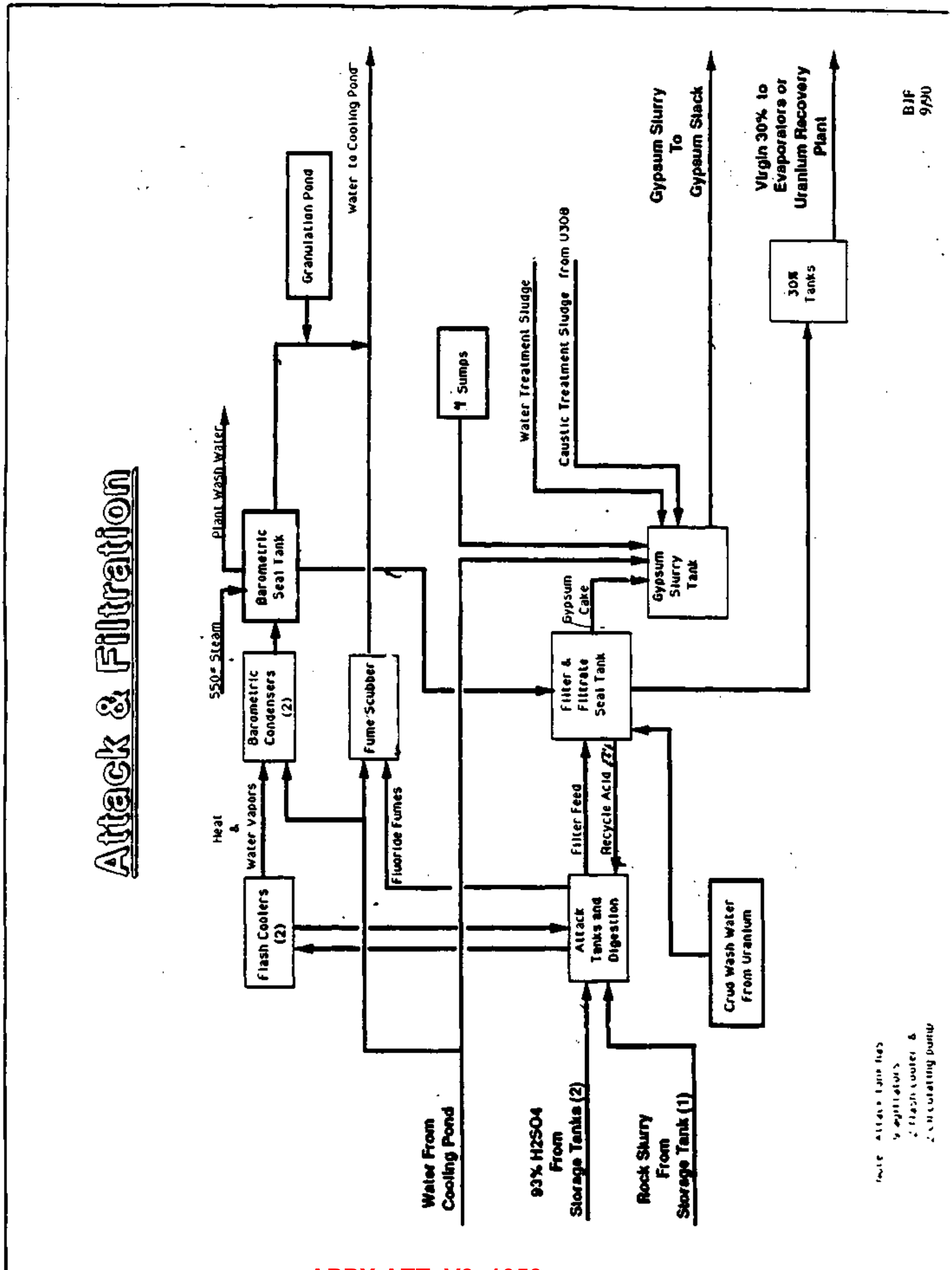
	Organization	Phone Number
Rusty Walker	Freeport	(504) 582-4232
George Chambers	Freeport	(504) 582-4259
Bob Dennis	Agrico	(504) 562-3501
Bob Sharshan	Agrico	(504) 562-3501
John Wen	Agrico	(504) 562-3501
Susan Stewart	Agrico	(504) 493-5904
Bob Hall	EPA	(703) 308-8412
Scott Ellinger	EPA	(703) 308-8410
Frank Smith	EPA	(202) 382-2791
David Bauer	ICF Incorporated	(703) 934-3697
Rich Pierce	ICF Incorporated	(703) 934-3554
Ron Rimelman	SAIC	(703) 821-4861
John Martinez	Badger Design and Constructors, Inc.	(813) 289-1991

EXHIBIT 2
BLOCK FLOW DIAGRAMS FOR AGRICO/UNCLE SAM

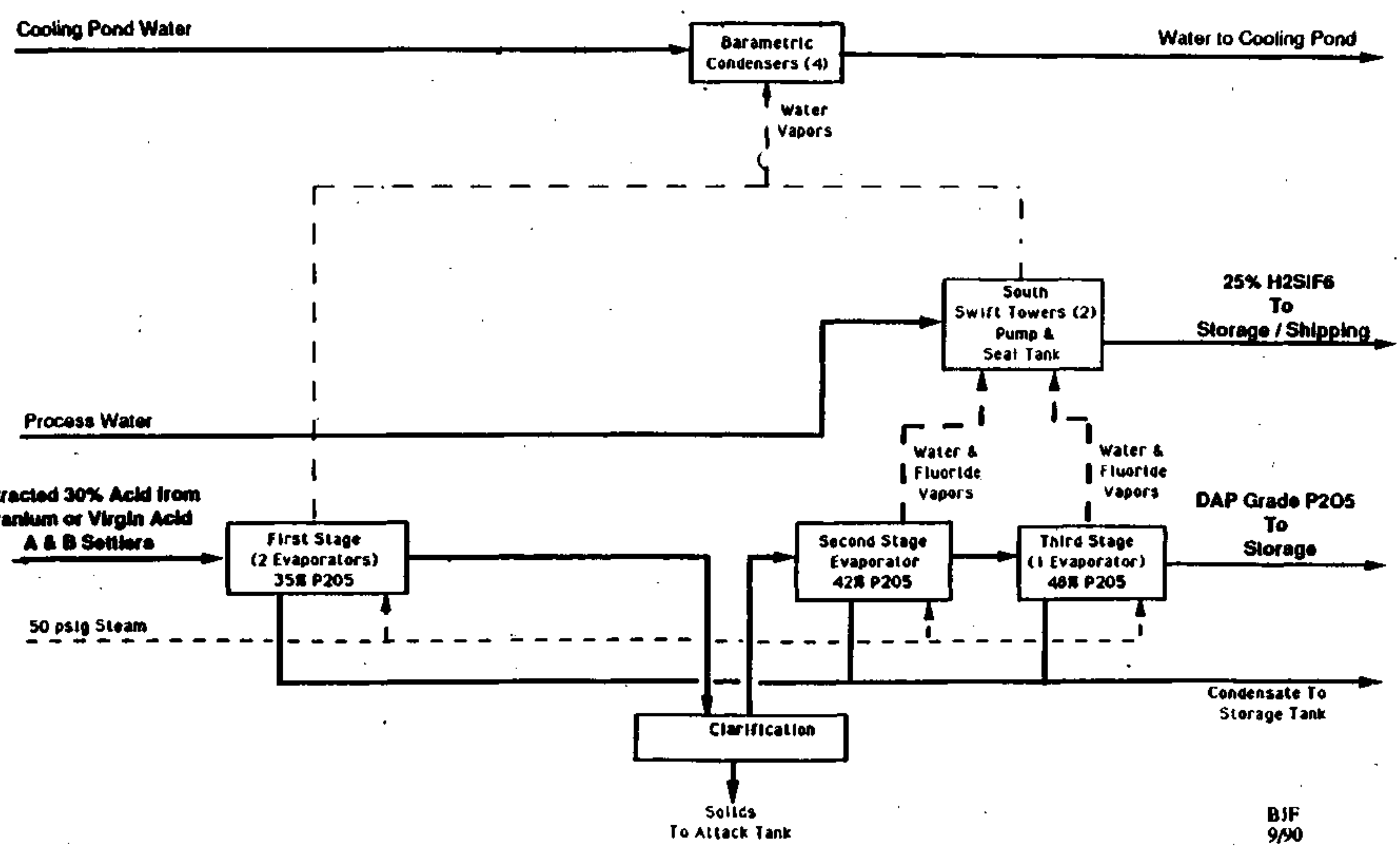


Ball Mill


Clarified River Water, Lime Treated Cooling Pond Water, or Lime Treated Seepage Ditch Water
1
2
3
Wet Phosphate Rock From Barges
4
Conveyer Belts
Stacker
Rock Piles
Reclaimer
Rock Silo
Ramsey Scale
Iron Balls
Ball Mill
Feed
Cyclone Header
Fines Overflow
Coarse Underflow
Rock Slurry Storage Tank
5
Ground Rock Slurry To Attack Tanks
BJF
9/90


Attack & Filtration
Heat & water vapors
Flash Coolers (2)
Barometric Condensers (2)
550° Steam
Barometric Seal Tank
Plant Wash Water
Granulation Pond
Water to Cooling Pond
Fume Scubber
Fluoride Fumes
Attack Tanks and Digestion
Filter Feed
Recycle Acid 22%
Filter & Filtrate Seal Tank
Gypsum Cake
Gypsum Slurry Tank
4 Sumps
Water Treatment Sludge
Caustic Treatment Sludge from U308
Gypsum Slurry To Gypsum Stack
30% Tanks
Virgin 30% to Evaporators or Uranium Recovery Plant
Crud Wash Water From Uranium
Water From Cooling Pond
93% H2SO4 From Storage Tanks (2)
Rock Slurry From Storage Tank (1)
BJF 9/90

Evaporators & Swift Towers



APPENDIX B - DETAILED COST TABLES

APPENDIX B1

Lime treat the cooling water, gypsum slurry, leachate/runoff from the existing gypsum stack, and the existing cooling pond.

B1 - 1

INCREMENTAL CAPITAL COSTS FOR ENGINEERING ALTERNATIVE 1
(Treat slurry and cooling water)
(in $ thousands)

UNIT	C	TOTAL	C-/D+	TOTAL
LIME TREATMENT			Same costs as C scenario	
Lime Receiving and Slaking				
Lime Pneumatic Car Unloading System[1]	128.6			
Lime Storage Bin with Activator	99.1			
Lime Slaking System[2]	158.5			
Lime Slurry Transfer Pump (to gypsum tank)	10.0			
Cooling Pond Lime Pump (to neutralization mixing basin)	18.7			
Lime Slurry Piping	24.0			
Subtotal		438.9		
Neutralization Mixing Basin				
Concrete Basin with HDPE Liner	131.0			
Mixing Basin Piping	200.0			
Jet Mixing Recirculating Pump	180.0			
Subtotal		511.0		
Associated Items				
Piping	195.0			
Electrical	68.0			
Instrumentation	107.0			
Civil Works[3]	97.0			
Insulation and Painting	19.0			
Subtotal		486.0		
Construction				
Labor	965.0			
Management	138.0			
Overhead	448.0			
Subtotal		1,551.0		
Subtotal for Lime Treatment		**2,986.9**		**2,986.9**
ADDITIONAL FILTRATION			Same costs as C scenario	
UCEGO Table Filter	2,151.8	**2,151.8**		**2,151.8**
CaF_2 SLUDGE DISPOSAL IMPOUNDMENT			Same costs as C scenario	
Rural Land Acquisition	47.9			
Site Preparation	570.4			
Excavation	1,498.1			
Perimeter Road	9.7			
Subtotal		**2,126.1**		**2,126.1**

[1] Includes rail car flexible connector; lime unloading receiver, dust collector; receiver air lock; unloading air blower (vacuum); lime transfer air blower (pressure).

[2] Includes lime slurry tank agitator; lime feeder; lime slaker; seal water filter; and lime slurry tank.

[3] Includes structures; fire protection; buildings; foundations, paving, and miscellaneous; sewers; and site development and miscellaneous.

B1 - 2

INCREMENTAL CAPITAL COSTS FOR ENGINEERING ALTERNATIVE 1
(Treat slurry and cooling water)
(in $ thousands)

UNIT	C	TOTAL	C-/D+	TOTAL
STACK LEACHATE/RUNOFF POND				
Rural Land Acquisition	38.7		38.7	
Site Preparation	470.4		470.4	
Excavation	308.5		308.5	
Perimeter Road	8.7		8.7	
Synthetic Liner	4,141.8		2,070.9	
Geotech Liner	808.2		0.0	
Clay Liner, 3 ft., 20 mi.	7,461.1		7,461.1	
Sand Liner, 1ft., 20 mi.	2,513.0		0.0	
Leachate Collection	851.4		0.0	
Waste Analysis	5.0		5.0	
Runon/off Control	324.9		324.9	
Site Security	268.5		268.5	
Ground-Water Monitoring Wells	86.1		86.1	
Subtotal		17,286.3		11,042.8
TOTAL		24,551.1		18,307.6

B1 - 3

INCREMENTAL OPERATING AND MAINTENANCE AND OTHER ANNUAL COSTS FOR ENGINEERING ALTERNATIVE 1 (Treat slurry and cooling water) (in $ thousands)				
UNIT	C	TOTAL	C-/D+	TOTAL
LIME TREATMENT			Same costs as C scenario	
Variable Costs				
Raw Materials	5,863.0			
Labor: Operating	242.0			
Supervisor	37.0			
Maintenance/Repair	161.0			
Utilities: Electricity	161.0			
Operating Supplies	25.0			
Laboratory Services	37.0			
Subtotal		6,526.0		6,526.0
Overhead Costs				
Administrative	97.0			
Property Tax & Insurance	59.3			
Subtotal		156.3		156.3
Subtotal for Lime Treatment		**6,682.3**		**6,682.3**
ADDITIONAL FILTRATION			Same costs as C scenario	
UCEGO Table Filter	1,351.1			
Property Tax & Insurance	43.0			
Credit for Additional P_2O_5 Recovered	(2,190.0)			
Credit for Lime Savings	(445.0)			
Subtotal		**(1,240.9)**		**(1,240.9)**
ACID LOSSES			Same costs as C scenario	
Additional Sulfuric Acid Needed	138.0			
Production Loss from Scaling	3,786.5			
Production Loss to Reduced Filter Efficiency	113.6			
Subtotal		**4,038.1**		**4,038.1**
CaF_2 SLUDGE DISPOSAL IMPOUNDMENT			Same costs as C scenario	
Labor: Operating	218.0			
Maintenance	57.1			
Utilities and Other Miscellaneous Costs	63.6			
Perimeter Road	0.7			
Property Tax & Insurance	42.5			
Subtotal		**381.9**		**381.9**

INCREMENTAL OPERATING AND MAINTENANCE AND OTHER ANNUAL COSTS FOR ENGINEERING ALTERNATIVE 1
(Treat slurry and cooling water)
(in $ thousands)

UNIT	C	TOTAL	C-/D+	TOTAL
STACK LEACHATE/RUNOFF POND				
Perimeter Road	0.7		0.7	
Leachate Collection	42.1		0.0	
Leachate Treatment	24.5		0.0	
Labor: Operating	261.7		261.7	
Maintenance	50.7		50.7	
Utilities and Other Miscellaneous Costs	50.0		50.0	
Runon/off Controls	1.3		1.3	
Site Security	13.3		13.3	
Ground-Water Monitoring Well Maintenance	4.3		4.3	
Ground-Water Monitoring Analysis	115.6		115.6	
Financial Assurance	6.2		6.2	
Property Tax & Insurance	345.7		220.9	
Subtotal		916.1		724.7
PERMITS AND ENVIRONMENTAL LIABILITY INSURANCE		337.0	Same costs as C scenario	337.0
TOTAL		11,114.5		10,923.1

INCREMENTAL CLOSURE AND POST-CLOSURE COSTS FOR ENGINEERING ALTERNATIVE 1
(in $ Thousands)

MANAGEMENT UNIT	C	TOTAL	C-/D+	TOTAL
STACK LEACHATE/RUNOFF POND (C-/D+)			Same costs as C scenario	
Closure				
Topsoil and Grass	406.4			
Supervision and Certification	6.4			
Equipment Decontamination	0.4			
Subtotal		413.2		413.2

APPENDIX B2A

Lime treat the gypsum slurry, gypsum stack leachate/runoff, and existing cooling pond, and recover fluosilicic acid (FSA) from the cooling water with supplemental lime treatment using single-stage recovery.

B2A - 1

INCREMENTAL CAPITAL COSTS FOR ENGINEERING ALTERNATIVE 2A
(Treat slurry and recover FSA/treat cooling water)
(in $ thousands)

UNIT	C	TOTAL	C-/D+	TOTAL
LIME TREATMENT			Same Costs as C scenario	
Lime Receiving and Slaking				
Lime Pneumatic Car Unloading System[1]	128.6			
Lime Storage Bin with Activator	99.1			
Lime Slaking System[2]	158.5			
Lime Slurry Transfer Pump (to gypsum tank)	10.0			
Cooling Pond Lime Pump (to neutralization mixing basin)	18.7			
Lime Slurry Piping	24.0			
Subtotal		438.9		
Neutralization Mixing Basin				
Concrete Basin with HDPE Liner	131.0			
Mixing Basin Piping	200.0			
Jet Mixing Recirculating Pump	180.0			
Subtotal		511.0		
Associated Items				
Piping	195.0			
Electrical	68.0			
Instrumentation	107.0			
Civil Works[3]	97.0			
Insulation and Painting	19.0			
Subtotal		486.0		
Construction				
Labor	965.0			
Management	138.0			
Overhead	448.0			
Subtotal		1,551.0		
Subtotal for Lime Treatment		**2,986.9**		**2,986.9**
ADDITIONAL FILTRATION			Same costs as C scenario	
UCEGO Table Filter	2,151.8	**2,151.8**		**2,151.8**

[1] Includes rail car flexible connector; lime unloading receiver, dust collector; receiver air lock; unloading air blower (vacuum); and lime transfer air blower (pressure).

[2] Includes lime slurry tank agitator; lime feeder; lime slaker; seal water filter; and lime slurry tank.

[3] Includes structures; fire protection; buildings; foundations, paving, and miscellaneous; sewers; and site development and miscellaneous.

B2A - 2

INCREMENTAL CAPITAL COSTS FOR ENGINEERING ALTERNATIVE 2A
(Treat slurry and recover FSA/treat cooling water)
(in $ thousands)

UNIT	C	TOTAL	C-/D+	TOTAL
FSA RECOVERY			Same costs as C scenario	
Single-Stage FSA Recovery Units				
(Reaction and Evaporation)				
Vessels and Tanks[4]	961.0			
Pumps[5]	63.6			
Subtotal		1,024.6		
Associated Items				
Piping	687.1			
Electrical	21.1			
Instrumentation	14.9			
Structures	290.1			
Foundations, Paving, and Miscellaneous	89.7			
Painting	2.9			
Subtotal		1,105.8		
Construction				
Labor	1,063.2			
Management	151.9			
Overhead	590.5			
Subtotal		1,805.6		
Subtotal for FSA Recovery		**3,936.0**		**3,936.0**
CaF_2 SLUDGE DISPOSAL IMPOUNDMENT			Same costs as C scenario	
Rural Land Acquisition	19.5			
Site Preparation	251.7			
Excavation	405.1			
Perimeter Road	6.1			
Subtotal		**682.4**		**682.4**

[4] Includes reactor first-stage FSA; recovery vessel: reactor FSA recirculation tank; first-stage evaporator FSA recircu... second-stage evaporator first-stage FSA recovery vessel: and second-stage evaporator FSA recirculation tank.

[5] Includes reactor FSA recirculation pump: first-stage evaporator FSA recirculation pump: and second-stage evapor... recirculation pump.

INCREMENTAL CAPITAL COSTS FOR ENGINEERING ALTERNATIVE 2A (Treat slurry and recover FSA/treat cooling water) (in $ thousands)				
UNIT	C	TOTAL	C-/D+	TOTAL
STACK LEACHATE/RUNOFF POND				
Rural Land Acquisition	38.7		38.7	
Site Preparation	470.4		470.4	
Excavation	308.5		308.5	
Perimeter Road	8.7		8.7	
Synthetic Liner	4,141.8		2,070.9	
Geotech Liner	808.2		0.0	
Clay Liner, 3 ft., 20 mi.	7,461.1		7,461.1	
Sand Liner, 1ft., 20 mi.	2,513.0		0.0	
Leachate Collection	851.4		0.0	
Waste Analysis	5.0		5.0	
Runon/off Control	324.9		324.9	
Site Security	268.5		268.5	
Ground-Water Monitoring Wells	86.1		86.1	
Subtotal		17,286.3		11,042.8
TOTAL		27,043.4		20,799.9

B2A - 4

INCREMENTAL OPERATING AND MAINTENANCE AND OTHER ANNUAL COSTS FOR ENGINEERING ALTERNATIVE 2A
(Treat slurry and recover FSA (single-stage)/treat cooling water)
(in $ thousands)

UNIT	C	TOTAL	C-/D+	TOTAL
LIME TREATMENT			Same	
Variable Costs			costs as	
Raw Materials	2,984.0		C	
Labor: Operating	123.0		scenario	
Supervisor	19.0			
Maintenance/Repair	82.0			
Utilities: Electricity	82.0			
Operating Supplies	13.0			
Laboratory Services	19.0			
Subtotal		3,322.0		3,322.0
Overhead Costs				
Administrative	50.0			
Property Tax & Insurance	59.3			
Subtotal		109.3		109.3
Subtotal for Lime Treatment		3,431.3		3,431.3
ADDITIONAL FILTRATION			Same	
UCEGO Table Filter	1,351.1		costs as	
Property Tax & Insurance	43.0		C	
Credit for Additional P_2O_5 Recovered	(2,190.0)		scenario	
Credit for Lime Savings	(445.0)			
Subtotal		(1240.9)		(1240.9)
FSA RECOVERY			Same	
Single-Stage FSA Recovery Units			costs as	
(Reaction and Evaporation)			C	
Labor: Operating and Maintenance	80.3		scenario	
Maintenance Materials	197.1			
Utilities: Electricity	127.8			
Laboratory Services	32.9			
Property Tax & Insurance	78.7			
Subtotal		516.8		516.8
ACID LOSSES			Same	
Additional Sulfuric Acid Needed	138.0		costs as	
Production Loss from Scaling	3,786.5		C	
Production Loss to Reduced Filter Efficiency	113.6		scenario	
Subtotal		4,038.1		4,038.1
CaF_2 SLUDGE DISPOSAL IMPOUNDMENT			Same	
Labor: Operating	218.0		costs as	
Maintenance	33.9		C	
Utilities and Other Miscellaneous Costs	22.4		scenario	
Perimeter Road	0.5			
Property Tax & Insurance	13.6			
Subtotal		288.4		288.4

B2A - 5

INCREMENTAL OPERATING AND MAINTENANCE AND OTHER ANNUAL COSTS FOR ENGINEERING ALTERNATIVE 2A
(Treat slurry and recover FSA (single-stage)/treat cooling water)
(in $ thousands)

UNIT	C	TOTAL	C-/D+	TOTAL
STACK LEACHATE/RUNOFF POND				
Perimeter Road	0.7		0.7	
Leachate Collection	42.1		0.0	
Leachate Treatment	24.5		0.0	
Labor: Operating	261.7		261.7	
Maintenance	50.7		50.7	
Utilities and Other Miscellaneous Costs	50.0		50.0	
Runon/off Controls	1.3		1.3	
Site Security	13.3		13.3	
Ground-Water Monitoring Well Maintenance	4.3		4.3	
Ground-Water Monitoring Analysis	115.6		115.6	
Financial Assurance	6.2		6.2	
Property Tax & Insurance	345.7		220.9	
Subtotal		916.1		724.7
PERMITS AND ENVIRONMENTAL IMPAIRMENT LIABILITY INSURANCE		337.0	Same costs as C scenario	337.0
FSA SALES CREDIT		(2,489.3)	Same costs as C scenario	(2,489.3)
TOTAL		5,797.5		5,606.1

B2A - 6

INCREMENTAL CLOSURE AND POST-CLOSURE COSTS FOR ENGINEERING ALTERNATIVE 2A (in $ Thousands)				
MANAGEMENT UNIT	C	TOTAL	C-/D+	TOTAL
STACK LEACHATE/RUNOFF POND (C-/D+)			Same costs as C scenario	
Closure				
Topsoil and Grass	406.4			
Supervision and Certification	6.4			
Equipment Decontamination	0.4			
Subtotal		413.2		413.2

APPENDIX B2B

Lime treat the gypsum slurry, gypsum stack leachate/runoff, and existing cooling pond, and recover fluosilicic acid (FSA) from the cooling water with supplemental lime treatment using double-stage recovery.

B2B - 1

INCREMENTAL CAPITAL COSTS FOR ENGINEERING ALTERNATIVE 2B
(Treat slurry and recover FSA/treat cooling water)
(in $ thousands)

UNIT	C	TOTAL	C-/D+	TOTAL
LIME TREATMENT			Same costs as C scenario	
Lime Receiving and Slaking				
Lime Pneumatic Car Unloading System[1]	128.6			
Lime Storage Bin with Activator	99.1			
Lime Slaking System[2]	158.5			
Lime Slurry Transfer Pump (to gypsum tank)	10.0			
Cooling Pond Lime Pump (to neutralization mixing basin)	18.7			
Lime Slurry Piping	24.0			
Subtotal		438.9		
Neutralization Mixing Basin				
Concrete Basin with HDPE Liner	131.0			
Mixing Basin Piping	200.0			
Jet Mixing Recirculating Pump	180.0			
Subtotal		511.0		
Associated Items				
Piping	195.0			
Electrical	68.0			
Instrumentation	107.0			
Civil Works[3]	97.0			
Insulation and Painting	19.0			
Subtotal		486.0		
Construction				
Labor	965.0			
Management	138.0			
Overhead	448.0			
Subtotal		1,551.0		
Subtotal for Lime Treatment		**2,986.9**		**2,986.9**
ADDITIONAL FILTRATION			Same costs as C scenario	
UCEGO Table Filter	2,151.8	**2,151.8**		**2,151.8**

[1] Includes rail car flexible connector; lime unloading receiver, dust collector; receiver air lock; unloading air blower (vacuum); and lime transfer air blower (pressure).

[2] Includes lime slurry tank agitator; lime feeder; lime slaker; seal water filter; and lime slurry tank.

[3] Includes structures; fire protection; buildings; foundations, paving, and miscellaneous; sewers; and site development and miscellaneous.

B2B - 2

INCREMENTAL CAPITAL COSTS FOR ENGINEERING ALTERNATIVE 2B
(Treat slurry and recover FSA/treat cooling water)
(in $ thousands)

UNIT	C	TOTAL	C-/D+	TOTAL
FSA RECOVERY			Same costs as C scenario	
Double-Stage FSA Recovery Units				
(Reaction and Evaporation)				
Vessels and Tanks[4]	1,922.0			
Pumps[5]	127.2			
Subtotal		2,049.2		
Associated Items				
Piping	1,374.2			
Electrical	42.2			
Instrumentation	29.8			
Structures	580.2			
Foundations, Paving, and Miscellaneous	179.4			
Painting	5.8			
Subtotal		2,211.6		
Construction				
Labor	2,126.4			
Management	303.8			
Overhead	1,181.0			
Subtotal		3,611.2		
Subtotal for FSA Recovery		**7,872.0**		**7,872.0**
CaF_2 SLUDGE DISPOSAL IMPOUNDMENT			Same costs as C scenario	
Rural Land Acquisition	7.3			
Site Preparation	102.5			
Excavation	86.5			
Perimeter Road	3.5			
Subtotal		**199.8**		**199.8**

[4] Includes reactor first-stage FSA; recovery vessel; reactor FSA recirculation tank; first-stage evaporator FSA recircul... second-stage evaporator first-stage FSA recovery vessel; and second-stage evaporator FSA recirculation tank.

[5] Includes reactor FSA recirculation pump; first-stage evaporator FSA recirculation pump; and second-stage evapora... recirculation pump.

B2B - 3

INCREMENTAL CAPITAL COSTS FOR ENGINEERING ALTERNATIVE 2B
(Treat slurry and recover FSA/treat cooling water)
(in $ thousands)

UNIT	C	TOTAL	C-/D+	TOTAL
STACK LEACHATE/RUNOFF POND				
Rural Land Acquisition	38.7		38.7	
Site Preparation	470.4		470.4	
Excavation	308.5		308.5	
Perimeter Road	8.7		8.7	
Synthetic Liner	4,141.8		2,070.9	
Geotech Liner	808.2		0.0	
Clay Liner, 3 ft., 20 mi.	7,461.1		7,461.1	
Sand Liner, 1ft., 20 mi.	2,513.0		0.0	
Leachate Collection	851.4		0.0	
Waste Analysis	5.0		5.0	
Runon/off Control	324.9		324.9	
Site Security	268.5		268.5	
Ground-Water Monitoring Wells	86.1		86.1	
Subtotal		17,286.3		11,042.8
TOTAL		30,496.8		24,253.3

INCREMENTAL OPERATING AND MAINTENANCE AND OTHER ANNUAL COSTS FOR ENGINEERING ALTERNATIVE 2B
(Treat slurry and recover FSA (double-stage)/treat cooling water)
(in $ thousands)

UNIT	C	TOTAL	C-/D+	TOTAL
LIME TREATMENT			Same costs as C scenario	
Variable Costs				
Raw Materials	2,283.0			
Labor: Operating	94.0			
Supervisor	14.0			
Maintenance/Repair	63.0			
Utilities: Electricity	63.0			
Operating Supplies	10.0			
Laboratory Services	14.0			
Subtotal		2,541.0		2,541.0
Overhead Costs				
Administrative	38.0			
Property Tax & Insurance	59.3			
Subtotal		97.3		97.3
Subtotal for Lime Treatment		**2,638.3**		**2,638.3**
ADDITIONAL FILTRATION			Same costs as C scenario	
UCEGO Table Filter	1,351.1			
Property Tax & Insurance	43.0			
Credit for Additional P_2O_5 Recovered	(2,190.0)			
Credit for Lime Savings	(445.0)			
Subtotal		**(1240.9)**		**(1240.9)**
FSA RECOVERY			Same costs as C scenario	
Double-Stage FSA Recovery Units				
(Reaction and Evaporation)				
Labor: Operating and Maintenance	160.6			
Maintenance Materials	394.2			
Utilities: Electricity	255.6			
Laboratory Services	65.8			
Property Tax & Insurance	157.4			
Subtotal		**1,033.6**		**1,033.6**
ACID LOSSES			Same costs as C scenario	
Additional Sulfuric Acid Needed	138.0			
Production Loss from Scaling	3,786.5			
Production Loss to Reduced Filter Efficiency	113.6			
Subtotal		**4,038.1**		**4,038.1**
CaF_2 SLUDGE DISPOSAL IMPOUNDMENT			Same costs as C scenario	
Labor: Operating	218.0			
Maintenance	18.0			
Utilities and Other Miscellaneous Costs	6.4			
Perimeter Road	0.3			
Property Tax & Insurance	4.0			
Subtotal		**246.7**		[illegible]

B2B - 5

INCREMENTAL OPERATING AND MAINTENANCE AND OTHER ANNUAL COSTS FOR ENGINEERING ALTERNATIVE 2B
(Treat slurry and recover FSA (double-stage)/treat cooling water)
(in $ thousands)

UNIT	C	TOTAL	C-/D+	TOTAL
STACK LEACHATE/RUNOFF POND				
Perimeter Road	0.7		0.7	
Leachate Collection	42.1		0.0	
Leachate Treatment	24.5		0.0	
Labor: Operating	261.7		261.7	
Maintenance	50.7		50.7	
Utilities and Other Miscellaneous Costs	50.0		50.0	
Runon/off Controls	1.3		1.3	
Site Security	13.3		13.3	
Ground-Water Monitoring Well Maintenance	4.3		4.3	
Ground-Water Monitoring Analysis	115.6		115.6	
Financial Assurance	6.2		6.2	
Property Tax & Insurance	345.7		220.9	
Subtotal		916.1		724.7
PERMITS AND ENVIRONMENTAL IMPAIRMENT LIABILITY INSURANCE		337.0	Same costs as C scenario	337.0
FSA SALES CREDIT		(3,066.0)	Same costs as C scenario	(3,066.0)
TOTAL		4,902.9		4,711.5

B2B - 6

INCREMENTAL CLOSURE AND POST-CLOSURE COSTS FOR ENGINEERING ALTERNATIVE 2B
(in $ Thousands)

MANAGEMENT UNIT	C	TOTAL	C-/D+	TOTAL
STACK LEACHATE/RUNOFF POND (C-/D+)			Same costs as C scenario	
Closure				
Topsoil and Grass	406.4			
Supervision and Certification	6.4			
Equipment Decontamination	0.4			
Subtotal		413.2		413.2

APPENDIX B3

Construct a new gypsum stack, cooling pond, and stack leachate collection pond, all with liners.

B3 - 1

INCREMENTAL CAPITAL COSTS FOR ENGINEERING ALTERNATIVE 3
(Construct lined stack and lined cooling pond)
(in $ thousands)

UNIT	C-	TOTAL	D+	TOTAL
100-ACRE COOLING POND (C-/D+)			Same costs as C- scenario	
Rural Land Acquisition	71.7			
Site Preparation	823.5			
Excavation	580.4			
Perimeter Road	11.9			
Synthetic Liner	3,773.9			
Clay Liner, 3 ft. 20 mi.	13,881.7			
Waste Analysis	5.0			
Runon/off Controls	457.8			
Site Security	378.3			
Ground-Water Monitoring Wells	113.7			
Subtotal		**20,097.0**		**20,097.0**
LINED GYPSUM STACK				
Rural Land Acquisition	164.5		138.3	
Site Preparation	1,754.8		1,498.1	
Perimeter Road	14.7		13.6	
Synthetic Liner(s)	16,329.9		6,926.0	
Geotech Liner(s)	6,572.5		2,777.3	
Clay Liner, 3 ft, 20 mi	30,957.9		26,082.2	
Sand Liner(s), 1 ft, 20 mi	20,813.9		8,768.8	
Leachate Collection(s)	5,938.3		2,532.0	
Slurry Pipeline .5 km.	21.2		21.2	
Waste Analysis	5.0		5.0	
Dredging Equipment	197.1		197.1	
Runon/off Controls	716.4		653.1	
Site Security	342.2		315.2	
Ground-Water Monitoring Wells	156.8		144.3	
Subtotal		**83,985.2**		**50,072.2**
STACK LEACHATE/RUNOFF POND (C-/D+)			Same costs as C- scenario	
Rural Land Acquisition	38.7			
Site Preparation	470.4			
Excavation	308.5			
Perimeter Road	8.7			
Synthetic Liner	2,070.9			
Geotech Liner	0.0			
Clay Liner, 3 ft., 20 mi.	7,461.1			
Sand Liner, 1ft., 20 mi.	0.0			
Leachate Collection	0.0			
Waste Analysis	5.0			
Runon/off Control	324.9			
Site Security	268.5			
Ground-Water Monitoring Wells	86.1			
Subtotal		**11,042.8**		**11,042.8**
TOTAL		**115,125.0**		**81,212.0**

B3 - 2

INCREMENTAL OPERATING AND MAINTENANCE AND OTHER ANNUAL COSTS FOR ENGINEERING ALTERNATIVE 3
(Construct lined stack and lined cooling pond)
(in $ thousands)

UNIT	C-	TOTAL	D+	TOTAL
100-ACRE COOLING POND (C-/D+)			Same costs as C- scenario	
Labor: Operating	261.7			
Maintenance	71.4			
Utilities and Other Miscellaneous Costs	99.4			
Perimeter Road	0.9			
Run-on/off Controls	1.8			
Site Security	18.7			
Ground-Water Monitoring Well Maintenance	5.6			
Ground-Water Monitoring Analysis	151.9			
Property Tax & Insurance	402.0			
Financial Assurance	11.4			
Subtotal		1,024.8		1,024.8
LINED GYPSUM STACK				
Labor: Operating	25.9		25.8	
Maintenance	7.4		7.4	
Utilities and Other Miscellaneous Costs	122.4		101.6	
Dredging Equipment	309.8		309.8	
Perimeter Road	1.1		1.0	
Leachate Collection	294.0		125.3	
Leachate Treatment	80.1		69.7	
Run-on/off Control	2.9		2.6	
Site Security	16.9		15.6	
Ground-Water Monitoring Well Maintenance	7.8		7.1	
Ground-Water Monitoring Analysis	222.4		205.1	
Property Tax & Insurance	1,679.7		1001.4	
Financial Assurance	74.7		6.4	
Subtotal		2,845.1		1,878.8

B3 - 3

INCREMENTAL OPERATING AND MAINTENANCE AND OTHER ANNUAL COSTS FOR ENGINEERING ALTERNATIVE 3
(Construct lined stack and lined cooling pond)
(in $ thousands)

UNIT	C-	TOTAL	D+	TOTAL
STACK LEACHATE/RUNOFF POND (C-/D+)			Same costs as C- scenario	
Labor: Operating				
Maintenance	261.7			
Utilities and Other Miscellaneous Costs	50.7			
Perimeter Road	50.0			
Run-on/off Control	0.7			
Site Security	1.3			
Ground-Water Monitoring Well Maintenance	13.3			
Ground-Water Monitoring Analysis	4.3			
Property Tax & Insurance	115.6			
Financial Assurance	220.9			
Subtotal	6.2			
		724.7		724.7
PERMITS AND ENVIRONMENTAL IMPAIRMENT LIABILITY INSURANCE		337.0	Same costs as C- scenario	234.3
TOTAL		4,931.6		3,862.6

B3 - 4

INCREMENTAL CLOSURE AND POST-CLOSURE COSTS FOR ENGINEERING ALTERNATIVE 3
(Construct lined stack and lined cooling pond)
(in $ Thousands)

MANAGEMENT UNIT	C-	TOTAL	D+	TOTAL
100-ACRE COOLING POND (C-/D+)			Same costs as C- scenario	
Closure				
Topsoil and Grass	753.4			
Supervision and Certification	6.4			
Equipment Decontamination	0.4			
Subtotal		760.2		760.2
LINED GYPSUM STACK				
Closure				
Clay Liner, 3 ft., 20 mi.	972.9		0.0	
Sand Liner, 1 ft., 20 mi.	329.7		0.0	
Synthetic Liner	283.9		0.0	
Geotech Liner	106.0		0.0	
Topsoil and Grass	1,687.0		0.0	
Equipment Decontamination	0.4		0.0	
Superv. & Certification	6.4		6.4	
Subtotal		3,386.3		6.4
Post-Closure				
Leach Collection System Maint.	294.0		125.3	
Leachate Treatment	80.1		69.7	
Runon/off Controls	2.9		2.6	
Site Security	16.9		15.6	
Ground-Water Monitoring Wells	7.8		7.1	
Ground-Water Monitoring Analyses	222.4		205.1	
Mowing and Fertilizing	973.7		0.0	
Inspection/Reporting/Recordkeeping	2.5		2.5	
Subtotal		1,600.3		427.9
STACK LEACHATE/RUNOFF POND (C-/D+)			Same costs as C- scenario	
Closure				
Topsoil and Grass	406.4			
Supervision and Certification	6.4			
Equipment Decontamination	0.4			
Subtotal		413.2		413.2

APPENDIX B4

Construct a new, lined gypsum stack and lime treat the cooling water, the existing cooling pond, and leachate/runoff from the existing gypsum stack.

B4 - 1

INCREMENTAL CAPITAL COSTS FOR ENGINEERING ALTERNATIVE 4
(Construct lined stack and treat cooling water)
(in $ thousands)

UNIT	C-	TOTAL	D+	TOTAL
LIME TREATMENT			Same	
Lime Receiving and Slaking			costs as	
Lime Pneumatic Car Unloading System[1]	128.6		C-	
Lime Storage Bin with Activator	99.1		scenario	
Lime Slaking System[2]	158.5			
Lime Slurry Transfer Pump (to gypsum tank)	10.0			
Cooling Pond Lime Pump (to neutralization	18.7			
mixing basin)	24.0	438.9		
Lime Slurry Piping				
Subtotal				
Neutralization Mixing Basin				
Concrete Basin with HDPE Liner	131.0			
Mixing Basin Piping	200.0			
Jet Mixing Recirculating Pump	180.0			
Subtotal		511.0		
Associated Items				
Piping	195.0			
Electrical	68.0			
Instrumentation	107.0			
Civil Works[3]	97.0			
Insulation and Painting	19.0			
Subtotal		486.0		
Construction				
Labor	965.0			
Management	138.0			
Overhead	448.0			
Subtotal		1,551.0		
Subtotal for Lime Treatment		**2,986.9**		**2,986.9**
CaF_2 SLUDGE DISPOSAL IMPOUNDMENT			Same	
Rural Land Acquisition	47.9		costs as	
Site Preparation	570.4		C-	
Excavation	1,498.1		scenario	
Perimeter Road	9.7			
Subtotal		**2,126.1**		**2,126.1**

[1] Includes rail car flexible connector; lime unloading receiver, dust collector; receiver air lock; unloading air blower (vacuum), and lime transfer air blower (pressure).

[2] Includes lime slurry tank agitator; lime feeder; lime slaker; seal water filter; and lime slurry tank.

[3] Includes structures; fire protection; buildings; foundations, paving, and miscellaneous; sewers; and site development and miscellaneous.

B4 - 2

INCREMENTAL CAPITAL COSTS FOR ENGINEERING ALTERNATIVE 4
(Construct lined stack and treat cooling water)
(in $ thousands)

UNIT	C-	TOTAL	D+	TOTAL
STACK LEACHATE/RUNOFF POND (C-/D+)			Same costs as C- scenario	
Rural Land Acquisition	38.7			
Site Preparation	470.4			
Excavation	308.5			
Perimeter Road	8.7			
Synthetic Liner	2,070.9			
Clay Liner, 3 ft. 20 mi.	7,461.1			
Waste Analysis	5.0			
Runon/off	324.9			
Site Security	268.5			
Ground-Water Monitoring Wells	86.1			
Subtotal		11,042.8		11,042.8
COOLING POND EXPANSION - ADDITIONAL 50 ACRES			Same costs as C- scenario	
Rural Land Acquisition (150-acre pond)	104.6			
(Credit for current 100-acre pond)	(71.7)			
Site Preparation (150-acre pond)	1,161.7			
(Credit for current 100-acre pond)	(823.5)			
Excavation (150-acre pond)	851.9			
(Credit for current 100-acre pond)	(580.4)			
Perimeter Road (150-acre pond)	14.2			
(Credit for current 100-acre pond)	(11.9)			
G-W Monitoring Well (150-acre pond)	17.6			
(Credit for current 100-acre pond)	(14.8)			
Subtotal		647.7		647.7
LINED GYPSUM STACK				
Rural Land Acquisition	164.5		138.3	
Site Preparation	1,754.8		1,498.1	
Perimeter Road	14.7		13.6	
Synthetic Liner	16,329.9		6,926.0	
Geotech Liner	6,572.5		2,777.3	
Clay Liner, 3 ft, 20 mi	30,957.9		26,082.2	
Sand Liner, 1 ft, 20 mi	20,813.9		8,768.8	
Leachate Collection	5,938.3		2,532.0	
Slurry Pipeline .5 km.	21.2		21.2	
Waste Analysis	5.0		5.0	
Dredging Equipment	197.1		197.1	
Runon/off control	716.4		653.1	
Site Security	342.2		315.2	
Ground-Water Monitoring Wells	156.8		144.3	
Subtotal		83,985.2		50,072.2
TOTAL		100,788.7		66,875.7

INCREMENTAL OPERATING AND MAINTENANCE AND OTHER ANNUAL COSTS FOR ENGINEERING ALTERNATIVE 4
(Construct lined stack and treat cooling water)
(in $ thousands)

UNIT	C-	TOTAL	D+	TOTAL
LIME TREATMENT			Same	
Variable Costs			costs as	
Raw Materials	5,075.0		C-	
Labor: Operating	209.0		scenario	
Supervisor	32.0			
Maintenance/Repair	139.0			
Utilities: Electricity	140.0			
Operating Supplies	22.0			
Laboratory Services	32.0			
Subtotal		5,649.0		
Overhead Costs				
Administrative	84.0			
Property Tax & Insurance	59.3			
Subtotal		143.3		
Subtotal for Lime Treatment		5,792.3		5,792.3
CaF_2 SLUDGE DISPOSAL IMPOUNDMENT			Same	
Labor: Operating	218.0		costs as	
Maintenance	57.1		C-	
Utilities and Other Miscellaneous Costs	63.6		scenario	
Perimeter Road	0.7			
Property Tax & Insurance	42.5			
Subtotal		381.9		381.9
STACK LEACHATE/RUNOFF POND (C-/D+)			Same	
Labor: Operating			costs as	
Maintenance	261.7		C-	
Utilities and Other Miscellaneous Costs	50.7		scenario	
Perimeter Road	50.0			
Run-on/off Control	0.7			
Site Security	1.3			
Ground-Water Monitoring Well Maintenance	13.3			
Ground-Water Monitoring Analysis	4.3			
Property Tax & Insurance	115.6			
Financial Assurance	220.9			
Subtotal	6.2			
		724.7		724.7

INCREMENTAL OPERATING AND MAINTENANCE AND OTHER ANNUAL COSTS FOR ENGINEERING ALTERNATIVE 4
(Construct lined stack and treat cooling water)
(in $ thousands)

UNIT	C-	TOTAL	D+	TOTAL
COOLING POND EXPANSION - ADDITIONAL 50 ACRES			Same costs as C- scenario	
Labor: Operating (150-acre cooling pond)	218.0			
(Credit for current 100-acre cooling pond)	(218.0)			
Maintenance (150-acre cooling pond)	87.6			
(Credit for current 100-acre cooling pond)	(71.4)			
Utilities and Other Miscellaneous Costs (150-acre cooling pond)	150.0			
(Credit for current 100-acre cooling pond)	(99.4)			
Perimeter Road (150-acre cooling pond)	1.1			
(Credit for current 100-acre cooling pond)	(0.9)			
G-W Monitoring Wells Maint. (150-acre cooling pond)	0.9			
(Credit for current 100-acre cooling pond)	(0.7)			
Ground-Water Monitoring Analysis (150-acre cooling pond)	60.1			
(Credit for current 100-acre cooling pond)	(50.6)			
Property Tax & Insurance (150-acre cooling pond)	43.0			
(Credit for current 100-acre cooling pond)	(30.0)			
Subtotal		**89.7**		**89.7**
ACID LOSSES			Same costs as C- scenario	
Additional Sulfuric Acid Needed	138.0			
Production Loss from Scaling	3,786.5			
Production Loss to Reduced Filter Efficiency	113.6			
Subtotal		**4,038.1**		**4,038.1**
LINED GYPSUM STACK				
Labor: Operating	25.9		25.8	
Maintenance	7.4		7.4	
Utilities and Other Miscellaneous Costs	122.4		101.6	
Dredging Equipment	309.8		309.8	
Perimeter Road	1.1		1.0	
Leachate Collection	294.0		125.3	
Leachate Treatment	80.1		69.7	
Run-on/off Control	2.9		2.6	
Site Security	16.9		15.6	
Ground-Water Monitoring Well Maintenance	7.8		7.1	
Ground-Water Monitoring Analysis	222.4		205.1	
Property Tax & Insurance	1,679.7		1,001.4	
Financial Assurance	74.7		6.4	
Subtotal		**2,845.1**		**1,878.8**
PERMITS AND ENVIRONMENTAL IMPAIRMENT LIABILITY INSURANCE		**337.0**	Same costs as C- scenario	**234.3**
TOTAL		**14,208.8**		**13,139.8**

INCREMENTAL CLOSURE AND POST-CLOSURE COSTS FOR ENGINEERING ALTERNATIVE 4
(Construct lined stack and treat cooling water)
(in $ Thousands)

MANAGEMENT UNIT	C-	TOTAL	D+	TOTAL
STACK LEACHATE/RUNOFF POND (C-/D+)			Same costs as C- scenario	
Closure				
Topsoil and Grass	406.4			
Supervision and Certification	6.4			
Equipment Decontamination	0.4			
Subtotal		413.2		413.2
LINDED GYPSUM STACK				
Closure				
Clay Liner, 3 ft., 20 mi.	972.9		0.0	
Sand Liner, 1 ft., 20 mi.	329.7		0.0	
Synthetic Liner	283.9		0.0	
Geotech Liner	106.0		0.0	
Topsoil and Grass	1,687.0		0.0	
Equipment Decontamination	0.4		0.0	
Superv. & Certification	6.4		6.4	
Subtotal		3,386.3		6.4
Post-Closure				
Leach Collection System Maint.	294.0		125.3	
Leachate Treatment	80.1		69.7	
Runon/off Controls	2.9		2.6	
Site Security	16.9		15.6	
Ground-Water Monitoring Wells	7.8		7.1	
Ground-Water Monitoring Analyses	222.4		205.1	
Mowing and Fertilizing	973.7		0.0	
Inspection/Reporting/Recordkeeping	2.5		2.5	
Subtotal		1,600.3		427.9

APPENDIX B5A

Construct a new, lined gypsum stack, lime treat the existing cooling pond and gypsum stack leachate/runoff, and recover fluosilicic acid (FSA) from the cooling water with supplemental lime treatment using single-stage recovery.

B5A - 1

INCREMENTAL CAPITAL COSTS FOR ENGINEERING ALTERATIVES 5A
(Construct lined stack and recover FSA/treat)
(in $ thousands)

UNIT	C-	TOTAL	D+	TOTAL
LIME TREATMENT			Same costs as C- scenario	
Lime Receiving and Slaking				
Lime Pneumatic Car Unloading System[1]	128.6			
Lime Storage Bin with Activator	99.1			
Lime Slaking System[2]	158.5			
Lime Slurry Transfer Pump (to gypsum tank)	10.0			
Cooling Pond Lime Pump (to neutralization mixing basin)	18.7			
Lime Slurry Piping	24.0			
Subtotal		438.9		
Neutralization Mixing Basin				
Concrete Basin with HDPE Liner	131.0			
Mixing Basin Piping	200.0			
Jet Mixing Recirculating Pump	180.0			
Subtotal		511.0		
Associated Items				
Piping	195.0			
Electrical	68.0			
Instrumentation	107.0			
Civil Works[3]	97.0			
Insulation and Painting	19.0			
Subtotal		486.0		
Construction				
Labor	965.0			
Management	138.0			
Overhead	448.0			
Subtotal		1;551.0		
Subtotal for Lime Treatment		**2,986.9**		**2,986.9**

[1] Includes rail car flexible connector; lime unloading receiver, dust collector; receiver air lock; unloading air blower (vacuum); and lime transfer air blower (pressure).

[2] Includes lime slurry tank agitator; lime feeder; lime slaker; seal water filter; and lime slurry tank.

[3] Includes structures; fire protection; buildings; foundations, paving, and miscellaneous; sewers; and site development and miscellaneous.

INCREMENTAL CAPITAL COSTS FOR ENGINEERING ALTERATIVES 5A
(Construct lined stack and recover FSA/treat)
(in $ thousands)

UNIT	C-	TOTAL	D+	TOTAL
FSA RECOVERY			Same costs as C- scenario	
Single-Stage FSA Recovery Units				
(Reaction and Evaporation)				
Vessels and Tanks[4]	961.0			
Pumps[5]	63.6			
Subtotal		1,024.6		
Associated Items				
Piping	687.1			
Electrical	21.1			
Instrumentation	14.9			
Structures	290.1			
Foundations, Paving, and Miscellaneous	89.7			
Painting	2.9			
Subtotal		1,105.8		
Construction				
Labor	1,063.2			
Management	151.9			
Overhead	590.5			
Subtotal		1,805.6		
Subtotal for FSA Recovery		**3,936.0**		**3,936.0**
CaF_2 SLUDGE DISPOSAL IMPOUNDMENT			Same costs as C- scenario	
Rural Land Acquisition	19.5			
Site Preparation	251.7			
Excavation	405.1			
Perimeter Road	6.1			
Subtotal		**682.4**		**682.4**
STACK LEACHATE/RUNOFF POND (C-/D+)			Same costs as C- scenario	
Rural Land Acquisition	38.7			
Site Preparation	470.4			
Excavation	308.5			
Perimeter Road	8.7			
Synthetic Liner	2,070.9			
Clay Liner, 3 ft. 20 mi.	7,461.1			
Waste Analysis	5.0			
Runon/off Control	324.9			
Site Security	268.5			
Ground-Water Monitoring Wells	86.1			
Subtotal		**11,042.8**		**11,042.8**

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[4] Includes reactor first-stage FSA; recovery vessel; reactor FSA recirculation tank; first-stage evaporator FSA recircul[...] second-stage evaporator first-stage FSA recovery vessel; and second-stage evaporator FSA recirculation tank.

[5] Includes reactor FSA recirculation pump; first-stage evaporator FSA recirculation pump; and second-stage evapora[...] recirculation pump.

B5A - 3

INCREMENTAL CAPITAL COSTS FOR ENGINEERING ALTERNATIVES 5A
(Construct lined stack and recover FSA/treat)
(in $ thousands)

UNIT	C-	TOTAL	D+	TOTAL
COOLING POND EXPANSION - ADDITIONAL 50 ACRES			Same costs as C- scenario	
Rural Land Acquisition (150-acre pond)	104.6			
(Credit for Current 100-acre pond)	(71.7)			
Site Preparation (150-acre pond)	1,161.7			
(Credit for Current 100-acre pond)	(823.5)			
Excavation (150-acre pond)	851.9			
(Credit for Current 100-acre pond)	(580.4)			
Perimeter Road (150-acre pond)	14.2			
(Credit for Current 100-acre pond)	(11.9)			
G-W Monitoring Well (150-acre pond)	17.6			
(Credit for Current 100-acre pond)	(14.8)			
Subtotal		647.7		647.7
LINED GYPSUM STACK				
Rural Land Acquisition	164.5		138.3	
Site Preparation	1,754.8		1,498.1	
Perimeter Road	14.7		13.6	
Synthetic Liner	16,329.9		6,926.0	
Geotech Liner	6,572.5		2,777.3	
Clay Liner, 3 ft, 20 mi	30,957.9		26,082.2	
Sand Liner, 1 ft, 20 mi	20,813.9		8,768.8	
Leachate Collection	5,938.3		2,532.0	
Slurry Pipeline .5 km.	21.2		21.2	
Waste Analysis	5.0		5.0	
Dredging Equipment	197.1		197.1	
Runon/off	716.4		653.1	
Site Security	342.2		315.2	
Ground-Water Monitoring Wells	156.8		144.3	
Subtotal		83,985.2		50,072.2
TOTAL		103,281.0		69,368.0

INCREMENTAL OPERATING AND MAINTENANCE AND OTHER ANNUAL COSTS FOR ENGINEERING ALTERNATIVE 5A
(Construct lined stack and recover FSA (single-stage)/treat cooling water)
(in $ thousands)

UNIT	C-	TOTAL	D+	TOTAL
LIME TREATMENT			Same costs as C- scenario	
Variable Costs				
Raw Materials	2,196.0			
Labor: Operating	91.0			
Supervisor	14.0			
Maintenance/Repair	60.0			
Utilities: Electricity	60.0			
Operating Supplies	9.0			
Laboratory Services	14.0			
Subtotal		2,444.0		
Overhead Costs				
Administrative	37.0			
Property Tax & Insurance	59.3			
Subtotal		96.3		
Subtotal for Lime Treatment		2,540.3		2,540.3
FSA RECOVERY			Same costs as C- scenario	
Single-Stage FSA Recovery Units				
(Reaction and Evaporation)				
Labor: Operating and Maintenance	80.3			
Maintenance Materials	197.1			
Utilities: Electricity	127.8			
Laboratory Services	32.9			
Property Tax & Insurance	78.7			
Subtotal		516.8		516.8
CaF_2 SLUDGE DISPOSAL IMPOUNDMENT			Same costs as C- scenario	
Labor: Operating	218.0			
Maintenance	33.9			
Utilities and Other Miscellaneous Costs	22.4			
Perimeter Road	0.5			
Property Tax & Insurance	13.6			
Subtotal		288.4		288.4
STACK LEACHATE/RUNOFF POND (C-/D+)			Same costs as C- scenario	
Labor: Operating				
Maintenance	261.7			
Utilities and Other Miscellaneous Costs	50.7			
Perimeter Road	50.0			
Run-on/off Control	0.7			
Site Security	1.3			
Ground-Water Monitoring Well Maintenance	13.3			
Ground-Water Monitoring Analysis	4.3			
Property Tax & Insurance	115.6			
Financial Assurance	220.9			
Subtotal	6.2			
		724.7		

INCREMENTAL OPERATING AND MAINTENANCE AND OTHER ANNUAL COSTS FOR ENGINEERING ALTERNATIVE 5A
(Construct lined stack and recover FSA (single-stage)/treat cooling water)
(in $ thousands)

UNIT	C-	TOTAL	D+	TOTAL
COOLING POND EXPANSION - ADDITIONAL 50 ACRES			Same costs as C- scenario	
Labor: Operating (150-acre cooling pond)	218.0			
(Credit for current 100-acre cooling pond)	(218.0)			
Maintenance (150-acre cooling pond)	87.6			
(Credit for current 100-acre cooling pond)	(71.4)			
Utilities and Other Miscellaneous Costs (150-acre cooling pond)	150.0			
(Credit for current 100-acre cooling pond)	(99.4)			
Perimeter Road (150-acre cooling pond)	1.1			
(Credit for current 100-acre cooling pond)	(0.9)			
G-W Monitoring Wells Maint. (150-acre cooling pond)	0.9			
(Credit for current 100-acre cooling pond)	(0.7)			
Ground-Water Monitoring Analysis (150-acre cooling pond)	60.1			
(Credit for current 100-acre cooling pond)	(50.6)			
Property Tax & Insurance (150-acre cooling pond)	43.0			
(Credit for current 100-acre cooling pond)	(30.0)			
Subtotal		89.7		89.7
LINED GYPSUM STACK				
Labor: Operating	25.9		25.8	
Maintenance	7.4		7.4	
Utilities and Other Miscellaneous Costs	122.4		101.6	
Dredging Equipment	1.1		1.0	
Perimeter Road	309.8		309.8	
Leachate Collection	294.0		125.3	
Leachate Treatment	80.1		69.7	
Run-on/off Control	2.9		2.6	
Site Security	16.9		15.6	
Ground-Water Monitoring Well Maintenance	7.8		7.1	
Ground-Water Monitoring Analysis	222.4		205.1	
Property Tax & Insurance	1,679.7		1,001.4	
Financial Assurance	74.7		6.4	
Subtotal		2,845.1		1,878.8

INCREMENTAL OPERATING AND MAINTENANCE AND OTHER ANNUAL COSTS FOR ENGINEERING ALTERNATIVE 5A
(Construct lined stack and recover FSA (single-stage)/treat cooling water)
(in $ thousands)

UNIT	C-	TOTAL	D+	TOTAL
ACID LOSSES			Same costs as C- scenario	
Additional Sulfuric Acid Needed	138.0			
Production Loss from Scaling	3,786.5			
Production Loss to Reduced Filter Efficiency	113.6			
Subtotal		4,038.1		4,038.1
PERMITS AND ENVIRONMENTAL IMPAIRMENT LIABILITY INSURANCE		337.0	Same costs as C- scenario	234.3
FSA SALES CREDIT		(2,489.3)	Same costs as C- scenario	(2,489.3)
TOTAL		8,890.8		7,821.8

INCREMENTAL CLOSURE AND POST-CLOSURE COSTS FOR ENGINEERING ALTERNATIVE 5A
(Construct lined stack and recover FSA/treat cooling water)
(in $ Thousands)

MANAGEMENT UNIT	C-	TOTAL	D+	TOTAL
STACK LEACHATE/RUNOFF POND (C-/D+)			Same costs as C- scenario	
Closure				
Topsoil and Grass	406.4			
Supervision and Certification	6.4			
Equipment Decontamination	0.4			
Subtotal		413.2		413.2
LINED GYPSUM STACK				
Closure				
Clay Liner, 3 ft., 20 mi.	972.9		0.0	
Sand Liner, 1 ft., 20 mi.	329.7		0.0	
Synthetic Liner	283.9		0.0	
Geotech Liner	106.0		0.0	
Topsoil and Grass	1,687.0		0.0	
Equipment Decontamination	0.4		0.0	
Superv. & Certification	6.4		6.4	
Subtotal		3,386.3		6.4
Post-Closure				
Leach Collection System Maint.	294.0		125.3	
Leachate Treatment	80.1		69.7	
Runon/off Controls	2.9		2.6	
Site Security	16.9		15.6	
Ground-Water Monitoring Wells	7.8		7.1	
Ground-Water Monitoring Analyses	222.4		205.1	
Mowing and Fertilizing	973.7		0.0	
Inspection/Reporting/Recordkeeping	2.5		2.5	
Subtotal		1,600.3		427.9

APPENDIX B5B

Construct a new, lined gypsum stack, lime treat the existing cooling pond and gypsum stack leachate/runoff, and recover fluosilicic acid (FSA) from the cooling water with supplemental lime treatment using double-stage recovery.

B8 - 1

INCREMENTAL CAPITAL COSTS FOR BASELINE STACK AND BASELINE 100-ACRE COOLING POND (in $ thousands)		
UNIT	**COST**	**TOTAL**
100-ACRE COOLING POND		
Rural Land Acquisition	71.7	
Site Preperation	823.5	
Excavation	580.4	
Perimeter Road	11.9	
Ground-Water Monitoring Wells	14.8	
Subtotal		1,502.3
LINED GYPSUM STACK		
Rural Land Acquisition	138.3	
Site Preparation	1,498.1	
Perimeter Road	13.6	
Slurry Pipeline .5 km.	21.2	
Dredging Equipment	197.1	
Runon/off Controls	395.8	
Ground-Water Monitoring Wells	16.7	
Subtotal		2,280.8
TOTAL		3,783.1

INCREMENTAL OPERATING AND MAINTENANCE AND OTHER ANNUAL COSTS FOR BASELINE STACK AND BASELINE 100-ACRE COOLING POND
(Construct lined stack and lined cooling pond)
(in $ thousands)

UNIT	C-	TOTAL
100-ACRE COOLING POND		
Labor: Operating	218.0	
Maintenance	71.4	
Perimeter Road	0.9	
Utilities and Other Miscellaneous Costs	99.4	
Ground-Water Monitoring Well Maintenance	0.7	
Ground-Water Monitoring Analysis	50.6	
Property Tax & Insurance	30.0	
Subtotal		471.0
LINED GYPSUM STACK		
Labor: Operating	21.5	
Maintenance	7.4	
Utilities and Other Miscellaneous Costs	101.6	
Perimeter Road	1.0	
Dredging Equipment	309.8	
Ground-Water Monitoring Well Maintenance	0.8	
Ground-Water Monitoring Analysis	68.4	
Property Tax & Insurance	45.6	
Subtotal		556.1
TOTAL		1,027.1

APPENDIX B8

B7B - 7

INCREMENTAL CLOSURE AND POST-CLOSURE COSTS FOR ENGINEERING ALTERNATIVE 7B
(in $ Thousands)

MANAGEMENT UNIT	C	TOTAL	C-/D+	TOTAL
STACK LEACHATE/RUNOFF POND (C-/D+)			Same costs as C scenario	
Closure				
Topsoil and Grass	406.4			
Supervision and Certification	6.4			
Equipment Decontamination	0.4			
Subtotal		413.2		413.2

B7B - 5

INCREMENTAL OPERATING AND MAINTENANCE AND OTHER ANNUAL COSTS FOR ENGINEERING ALTERNATIVE 7B
(Treat slurry and recover FSA (double-stage)/closed-loop system
(in $ thousands)

UNIT	C	TOTAL	C/D+	TOTAL
LIME TREATMENT			Same costs as C scenario	
Variable Costs				
Raw Materials	1,790.0			
Labor: Operating	74.0			
Supervisor	11.0			
Maintenance/Repair	49.0			
Utilities: Electricity	49.0			
Operating Supplies	8.0			
Laboratory Services	11.0			
Subtotal		1,992.0		1,992.0
Overhead Costs				
Administrative	30.0			
Property Tax & Insurance	24.9			
Subtotal		54.9		54.9
Subtotal for Lime Treatment		2,046.9		2,046.9
ADDITIONAL FILTRATION			Same costs as C scenario	
UCEGO Table Filter	1,351.1			
Property & Insurance	43.0			
Credit for Additional P_2O_5 Recovered	(2,190.0)			
Credit for Lime-Savings	(445.0)			
Subtotal		(1,240.9)		(1,240.9)
FSA RECOVERY			Same costs as C scenario	
Double-Stage FSA Recovery Units				
(Reaction and Evaporation)				
Labor: Operating and Maintenance	160.6			
Maintenance Materials	394.2			
Utilities: Electricity	255.6			
Laboratory Services	65.8			
Property Tax & Insurance	157.4			
Subtotal		1,033.6		1,033.6
CLOSED-LOOP COOLING SYSTEM			Same costs as C scenario	
Maintenance and Repairs	812.0			
Utilities	850.0			
Operating Supplies	121.9			
Property Tax & Insurance	237.0			
Subtotal		2,020.9		2,020.9
COOLING TOWER			Same costs as C scenario	
Maintenance and Repairs	154.0			
Utilities	400.0			
Operating Supplies	23.1			
Property Tax & Insurance	44.9			
Subtotal		622.0		622.0

B7B - 6

INCREMENTAL OPERATING AND MAINTENANCE AND OTHER ANNUAL COSTS FOR ENGINEERING ALTERNATIVE 7B
(Treat slurry and recover FSA (double-stage)/closed-loop system
(in $ thousands)

UNIT	C	TOTAL	C-/D+	TOTAL
STACK LEACHATE/RUNOFF POND				
Perimeter Road	0.7		0.7	
Leachate Collection	42.1		0.0	
Leachate Treatment	24.5		0.0	
Labor: Operating	261.7		261.7	
Maintenance	50.7		50.7	
Utilities and Other Miscellaneous Costs	50.0		50.0	
Runon/off Controls	1.3		1.3	
Site Security	13.3		13.3	
Ground-Water Monitoring Well Maintenance	4.3		4.3	
Ground-Water Monitoring Analysis	115.6		115.6	
Financial Assurance	6.2		6.2	
Property Tax & Insurance	345.7		220.9	
Subtotal		916.1		724.7
ACID LOSSES			Same costs as C scenario	
Additional Sulfuric Acid Needed	138.0			
Production Loss from Scaling	3,786.5			
Production Loss to Reduced Filter Efficiency	113.6			
Subtotal		4,038.1		4,038.1
PERMITS AND ENVIRONMENTAL LIABILITY INSURANCE		337.0	Same costs as C scenario	337.0
FSA SALES CREDIT		(3,066.0)	Same costs as C scenario	(3,066.0)
TOTAL		6,707.7		6,516.3

INCREMENTAL CAPITAL COSTS FOR ENGINEERING ALTERNATIVE 7B (Treat slurry and recover FSA/closed-loop system) (in $ thousands)				
UNIT	C	TOTAL	C-/D+	TOTAL
COOLING TOWER			Same costs as C scenario	
Cooling Water Cooling Tower	600.0			
Cooling Tower Water Pumps	300.0			
Subtotal		900.0		
Associated Items				
Piping	206.0			
Electrical	72.0			
Instrumentation	113.0			
Civil Works[8]	103.0			
Insulation and Painting	21.0			
Subtotal		515.0		
Construction				
Labor	444.0			
Management	63.0			
Overhead	321.0			
Subtotal		828.0		
Subtotal for Cooling Tower		**2,243.0**		**2,243.0**

[8] Includes structures; fire protection; buildings; foundations, paving, and miscellaneous; sewers; and site development and miscellaneous.

B7B - 4

INCREMENTAL CAPITAL COSTS FOR ENGINEERING ALTERNATIVE 7B
(Treat slurry and recover FSA/closed-loop system)
(in $ thousands)

UNIT	C	TOTAL	C-/D+	TOTAL
STACK LEACHATE/RUNOFF POND				
Rural Land Acquisition	38.7		38.7	
Site Preparation	470.4		470.4	
Excavation	308.5		308.5	
Perimeter Road	8.7		8.7	
Synthetic Liner	4,141.8		2,070.9	
Geotech Liner	808.2		0.0	
Clay Liner, 3 ft., 20 mi.	7,461.1		7,461.1	
Sand Liner, 1ft., 20 mi.	2,513.0		0.0	
Leachate Collection	851.4		0.0	
Waste Analysis	5.0		5.0	
Runon/off Control	324.9		324.9	
Site Security	268.5		268.5	
Ground-Water Monitoring Wells	86.1		86.1	
Subtotal		17,286.3		11,042.8
TOTAL		42,652.3		36,408.8

B7B - 1

INCREMENTAL CAPITAL COSTS FOR ENGINEERING ALTERNATIVE 7B
(Treat slurry and recover FSA/closed-loop system)
(in $ thousands)

UNIT	C	TOTAL	C-/D+	TOTAL
LIME TREATMENT			Same costs as C scenario	
Lime Receiving and Slaking				
Lime Pneumatic Car Unloading System[1]	128.6			
Lime Storage Bin with Activator	99.1			
Lime Slaking System[2]	158.5			
Lime Slurry Transfer Pump (to gypsum tank)	10.0			
Lime Slurry Piping	11.0			
Subtotal		407.2		
Associated Items				
Piping	114.0			
Electrical	40.0			
Instrumentation	63.0			
Civil Works[3]	57.0			
Insulation and Painting	11.0			
Subtotal		285.0		
Construction				
Labor	320.0			
Management	46.0			
Overhead	187.0			
Subtotal		553.0		
Subtotal for Lime Treatment		1,245.2		1,245.2
ADDITIONAL FILTRATION			Same costs as C scenario	
UCEGO Table Filter	2,151.8	2,151.8		2,151.8

[1] Includes rail car flexible connector; lime unloading receiver, dust collector; receiver air lock; unloading air blower (vacuum); and lime transfer air blower (pressure).

[2] Includes lime slurry tank agitator; lime feeder; lime slaker; seal water filter; and lime slurry tank.

[3] Includes structures; fire protection; buildings; foundations, paving, and miscellaneous; sewers; and site development and miscellaneous.

B7B - 2

INCREMENTAL CAPITAL COSTS FOR ENGINEERING ALTERNATIVE 7B
(Treat slurry and recover FSA/closed-loop system)
(in $ thousands)

UNIT	C	TOTAL	C-/D+	TOTAL
FSA RECOVERY			Same costs as C scenario	
Double-Stage FSA Recovery Units				
(Reaction and Evaporation)				
Vessels and Tanks[4]	1922.0			
Pumps[5]	127.2			
Subtotal		2,049.2		
Associated Items				
Piping	1374.2			
Electrical	42.2			
Instrumentation	29.8			
Structures	580.2			
Foundations, Paving, and Miscellaneous	179.4			
Painting	5.8			
Subtotal		2,211.6		
Construction				
Labor	2,126.4			
Management	303.8			
Overhead	1181.0			
Subtotal		3,611.2		
Subtotal for FSA Recovery		**7,872.0**		**7,872.0**
CLOSED-LOOP COOLING SYSTEM			Same costs as C scenario	
Heat Exchanger System				
Barometric Condenser Water Coolers[6]	4,200.0			
Barometric Condenser Water Cooler Pumps[7]	300.0			
Subtotal		4,500.0		
Associated Items				
Piping	1,182.0			
Electrical	414.0			
Instrumentation	650.0			
Civil Works[8]	591.0			
Insulation and Painting	118.0			
Subtotal		2,955.0		
Construction				
Labor	2,838.0			
Construction Management	405.0			
Overhead	1,156.0			
Subtotal		4,399.0		
Subtotal for Closed-Loop Cooling System		**11,854.0**		**11,854.0**

[4] Includes reactor first-stage FSA; recovery vessel; reactor FSA recirculation tank; first-stage evaporator FSA recirculation tank; second-stage evaporator first-stage FSA recovery vessel; and second-stage evaporator FSA recirculation tank.

[5] Includes reactor FSA recirculation pump; first-stage evaporator FSA recirculation pump; and second-stage evaporator FSA recirculation pump.

[6] Includes one reactor water cooler and two evaporator water coolers.

[7] Includes one reactor water cooler and two evaporator water cooler pumps.

APPENDIX B7B

Lime treat the gypsum slurry and stack leachate/runoff, manage cooling water in a closed loop system using double-stage recovery, and deplete the existing cooling pond through recycle to the process.

INCREMENTAL CLOSURE AND POST-CLOSURE COSTS FOR ENGINEERING ALTERNATIVE 7A
(in $ Thousands)

MANAGEMENT UNIT	C	TOTAL	C-/D+	TOTAL
STACK LEACHATE/RUNOFF POND (C-/D+)			Same costs as C scenario	
Closure				
Topsoil and Grass	406.4			
Supervision and Certification	6.4			
Equipment Decontamination	0.4			
Subtotal		413.2		413.2

INCREMENTAL OPERATING AND MAINTENANCE AND OTHER ANNUAL COSTS FOR ENGINEERING ALTERNATIVE 7A
(Treat slurry and recover FSA (single-stage)/closed-loop system)
(in $ thousands)

UNIT	C	TOTAL	C-/D+	TOTAL
LIME TREATMENT			Same costs as C scenario	
Variable Costs				
Raw Materials	1,790.0			
Labor: Operating	74.0			
Supervisor	11.0			
Maintenance/Repair	49.0			
Utilities: Electricity	49.0			
Operating Supplies	8.0			
Laboratory Services	11.0			
Subtotal		1,992.0		1,992.0
Overhead Costs				
Administrative	30.0			
Property Tax & Insurance	24.9			
Subtotal		54.9		54.9
Subtotal for Lime Treatment		2,046.9		2,046.9
ADDITIONAL FILTRATION			Same costs as C scenario	
UCEGO Table Filter	1,351.1			
Property Tax & Insurance	43.00			
Credit for Additional P_2O_5 Recovered	(2,190.0)			
Credit for Lime Savings	(445.0)			
Subtotal		(1,240.9)		(1,240.9)
FSA RECOVERY			Same costs as C scenario	
Single-Stage FSA Recovery Units				
(Reaction and Evaporation)				
Labor: Operating and Maintenance	80.3			
Maintenance Materials	197.1			
Utilities: Electricity	127.8			
Laboratory Services	32.9			
Property Tax & Insurance	78.7			
Subtotal		516.8		516.8
CLOSED-LOOP COOLING SYSTEM			Same costs as C scenario	
Maintenance and Repairs	812.0			
Utilities	850.0			
Operating Supplies	121.9			
Property Tax & Insurance	237.0			
Subtotal		2,020.9		2,020.9
COOLING TOWER			Same costs as C scenario	
Maintenance and Repairs	154.0			
Utilities	400.0			
Operating Supplies	23.1			
Property Tax & Insurance	44.9			
Subtotal		622.0		622.0

B7A - 6

INCREMENTAL OPERATING AND MAINTENANCE AND OTHER ANNUAL COSTS FOR ENGINEERING ALTERNATIVE 7A
(Treat slurry and recover FSA (single-stage)/closed-loop system)
(in $ thousands)

UNIT	C	TOTAL	C-/D+	TOTAL
STACK LEACHATE/RUNOFF POND				
Perimeter Road	0.7		0.7	
Leachate Collection	42.1		0.0	
Leachate Treatment	24.5		0.0	
Labor: Operating	261.7		261.7	
Maintenance	50.7		50.7	
Utilities and Other Miscellaneous Costs	50.0		50.0	
Runon/off Controls	1.3		1.3	
Site Security	13.3		13.3	
Ground-Water Monitoring Well Maintenance	4.3		4.3	
Ground-Water Monitoring Analysis	115.6		115.6	
Financial Assurance	6.2		6.2	
Property Tax & Insurance	345.7		220.9	
Subtotal		916.1		724.7
ACID LOSSES			Same costs as C scenario	
Additional Sulfuric Acid Needed	138.0			
Production Loss from Scaling	3,786.5			
Production Loss to Reduced Filter Efficiency	113.6			
Subtotal		4,038.1		4,038.1
PERMITS AND ENVIRONMENTAL LIABILITY INSURANCE		337.0	Same costs as Cscenario	337.0
FSA SALES CREDIT		(2,489.3)	Same costs as C scenario	(2,489.3)
TOTAL		6,767.6		6,576.2

INCREMENTAL CAPITAL COSTS FOR ENGINEERING ALTERNATIVE 7A
(Treat slurry and recover FSA/closed-loop system)
(in $ thousands)

UNIT	C	TOTAL	C-/D+	TOTAL
COOLING TOWER			Same costs as C scenario	
Cooling Water Cooling Tower	600.0			
Cooling Tower Water Pumps	300.0			
Subtotal		900.0		
Associated Items				
Piping	206.0			
Electrical	72.0			
Instrumentation	113.0			
Civil Works[8]	103.0			
Insulation and Painting	21.0			
Subtotal		515.0		
Construction				
Labor	444.0			
Management	63.0			
Overhead	321.0			
Subtotal		828.0		
Subtotal for Cooling Tower		2,243.0		2,243.0

[8] Includes structures; fire protection; buildings; foundations, paving, and miscellaneous; sewers; and site development and miscellaneous.

INCREMENTAL CAPITAL COSTS FOR ENGINEERING ALTERNATIVE 7A
(Treat slurry and recover FSA/closed-loop system)
(in $ thousands)

UNIT	C	TOTAL	C-/D+	TOTAL
STACK LEACHATE/RUNOFF POND				
Rural Land Acquisition	38.7		38.7	
Site Preparation	470.4		470.4	
Excavation	308.5		308.5	
Perimeter Road	8.7		8.7	
Synthetic Liner	4,141.8		2,070.9	
Geotech Liner	808.2		0.0	
Clay Liner, 3 ft., 20 mi.	7,461.1		7,461.1	
Sand Liner, 1ft., 20 mi.	2,513.0		0.0	
Leachate Collection	851.4		0.0	
Waste Analysis	5.0		5.0	
Runon/off Control	324.9		324.9	
Site Security	268.5		268.5	
Ground-Water Monitoring Wells	86.1		86.1	
Subtotal		17,286.3		11,042.8
TOTAL		38,716.3		32,472.8

B7A - 1

INCREMENTAL CAPITAL COSTS FOR ENGINEERING ALTERNATIVE 7A
(Treat slurry and recover FSA/closed-loop system)
(in $ thousands)

UNIT	C	TOTAL	C-/D+	TOTAL
LIME TREATMENT			Same	
Lime Receiving and Slaking			costs as C	
Lime Pneumatic Car Unloading System[1]	128.6		scenario	
Lime Storage Bin with Activator	99.1			
Lime Slaking System[2]	158.5			
Lime Slurry Transfer Pump (to gypsum tank)	10.0			
Lime Slurry Piping	11.0			
Subtotal		407.2		
Associated Items				
Piping	114.0			
Electrical	40.0			
Instrumentation	63.0			
Civil Works[3]	57.0			
Insulation and Painting	11.0			
Subtotal		285.0		
Construction				
Labor	320.0			
Management	46.0			
Overhead	187.0			
Subtotal		553.0		
Subtotal for Lime Treatment		**1,245.2**		**1,245.2**
ADDITIONAL FILTRATION			Same costs as C	
UCEGO Table Filter	2,151.8	**2,151.8**	scenario	**2,151.8**

[1] Includes rail car flexible connector; lime unloading receiver, dust collector; receiver air lock; unloading air blower (vacuum), and lime transfer air blower (pressure).

[2] Includes lime slurry tank agitator; lime feeder; lime slaker; seal water filter; and lime slurry tank.

[3] Includes structures; fire protection; buildings; foundations, paving, and miscellaneous; sewers; and site development and miscellaneous.

B7A - 2

INCREMENTAL CAPITAL COSTS FOR ENGINEERING ALTERNATIVE 7A
(Treat slurry and recover FSA/closed-loop system)
(in $ thousands)

UNIT	C	TOTAL	C-/D+	TOTAL
FSA RECOVERY			Same	
Single-Stage FSA Recovery Units			costs as C	
(Reaction and Evaporation)			scenario	
Vessels and Tanks[4]				
Pumps[5]	961.0			
Subtotal	63.6			
Associated Items		1,024.6		
Piping				
Electrical	687.1			
Instrumentation	21.1			
Structures	14.9			
Foundations, Paving, and Miscellaneous	290.1			
Painting	89.7			
Subtotal	2.9			
Construction		1,105.8		
Labor	1,063.2			
Management	151.9			
Overhead	590.5			
Subtotal		1,805.6		
Subtotal for FSA Recovery		**3,936.0**		**3,936.0**
CLOSED-LOOP COOLING SYSTEM			Same	
Heat Exchanger System			costs as C	
Barometric Condenser Water Coolers[6]	4,200.0		scenario	
Barometric Condenser Water Cooler Pumps[7]	300.0			
Subtotal		4,500.0		
Associated Items				
Piping	1,182.0			
Electrical	414.0			
Instrumentation	650.0			
Civil Works[8]	591.0			
Insulation and Painting	118.0			
Subtotal		2,955.0		
Construction				
Labor	2,838.0			
Construction Management	405.0			
Overhead	1,156.0			
Subtotal		4,399.0		
Subtotal for Closed-Loop Cooling System		**11,854.0**		**11,854.0**

[4] Includes reactor first-stage FSA recovery vessel; reactor FSA recirculation tank; first-stage evaporator FSA recirculation tank; second-stage evaporator first-stage FSA recovery vessel; and second-stage evaporator FSA recirculation tank.

[5] Includes reactor FSA recirculation pump; first-stage evaporator FSA recirculation pump; and second-stage evaporator FSA recirculation pump.

[6] Includes one reactor water cooler and two evaporator water coolers.

[7] Includes one reactor water cooler and two evaporator water cooler pumps.

APPENDIX B7A

Lime treat the gypsum slurry and stack leachate/runoff, manage cooling water in a closed loop system using single-stage recovery, and deplete the existing cooling pond through recycle to the process.

INCREMENTAL CLOSURE AND POST-CLOSURE COSTS FOR ENGINEERING ALTERNATIVE 6
(Treat slurry and construct lined cooling pond)
(in $ Thousands)

MANAGEMENT UNIT	C-/D+	TOTAL
150-ACRE COOLING POND		
Closure		
Topsoil and Grass	1,090.5	
Supervision and Certification	6.4	
Equipment Decontamination	0.4	
Subtotal		1,097.3
Post-Closure		
Runon/off Controls	0.0	0.0

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INCREMENTAL OPERATING AND MAINTENANCE AND OTHER ANNUAL COSTS FOR ENGINEERING ALTERNATIVE 6
(Treat slurry and construct lined cooling pond)
(in $ thousands)

UNIT	C-/D+	TOTAL
LIME TREATMENT		
Variable Costs		
Raw Materials	1,790.0	
Labor: Operating	74.0	
Supervisor	11.0	
Maintenance/Repair	49.0	
Utilities: Electricity	49.0	
Operating Supplies	8.0	
Laboratory Services	11.0	
Subtotal		1,992.0
Overhead Costs		
Administrative	30.0	
Property Tax & Insurance	24.9	
Subtotal		54.9
Subtotal for Lime Treatment		2,046.9
ADDITIONAL FILTRATION		
UCEGO Table Filter	1,351.1	
Property Tax & Insurance	43.00	
Credit for Additional P_2O_5 Recovered	(2,190.0)	
Credit for Lime Savings	(445.0)	
Subtotal		(1,240.9)
150-ACRE COOLING POND		
Labor: Operating	261.7	
Maintenance	87.6	
Utilities and Other Miscellaneous Costs	150.0	
Perimeter Road	1.1	
Run-on/off Control	2.2	
Site Security	23.0	
G-W Monitoring Wells Maintenance	6.7	
Ground-Water Monitoring Analysis	180.3	
Property Tax & Insurance	578.1	
Financial Assurance	16.5	
Subtotal		1,307.2

INCREMENTAL OPERATING AND MAINTENANCE AND OTHER ANNUAL COSTS FOR ENGINEERING ALTERNATIVE 6
(Treat slurry and construct lined cooling pond)
(in $ thousands)

UNIT	C-/D+	TOTAL
STACK LEACHATE/RUNOFF POND		
Labor: Operating	261.7	
Maintenance	50.7	
Utilities and Other Miscellaneous Costs	50.0	
Perimeter Road	0.7	
Runon/off Controls	1.3	
Site Security	13.3	
Ground-Water Monitoring Well Maintenance	4.3	
Ground-Water Monitoring Analysis	115.6	
Financial Assurance	6.2	
Property Tax & Insurance	220.9	
Subtotal		724.7
PERMITS AND ENVIRONMENTAL IMPAIRMENT LIABILITY INSURANCE		**337.0**
TOTAL		**3,174.9**

INCREMENTAL CAPITAL COSTS FOR ENGINEERING ALTERNATIVE 6
(Treat slurry and construct lined cooling pond)
(in $ thousands)

UNIT	C-/D+	TOTAL
LIME TREATMENT		
Lime Receiving and Slaking		
Lime Pneumatic Car Unloading System[1]	128.6	
Lime Storage Bin with Activator	99.1	
Lime Slaking System[2]	158.5	
Lime Slurry Transfer Pump (to gypsum tank)	10.0	
Lime Slurry Piping	11.0	
Subtotal		407.2
Associated Items		
Piping	114.0	
Electrical	40.0	
Instrumentation	63.0	
Civil Works[3]	57.0	
Insulation and Painting	11.0	
Subtotal		285.0
Construction		
Labor	320.0	
Management	46.0	
Overhead	187.0	
Subtotal		553.0
Subtotal for Lime Treatment		1,245.2
ADDITIONAL FILTRATION		
UCEGO Table Filter	2,151.8	2,151.8
150-ACRE COOLING POND		
Rural Land Acquisition	104.6	
Site Preparation	1,161.7	
Excavation	851.9	
Perimeter Road	14.2	
Clay Liner, 2 ft., 20 mi.	20,191.5	
Synthetic Liner	5,414.8	
Waste Analysis	5.0	
Runon/off Control	562.2	
Site Security	464.6	
Ground-Water Monitoring Wells	135.5	
Subtotal		28,906.0

[1] Includes rail car flexible connector; lime unloading receiver, dust collector; receiver air lock; unloading air blower (vacuum) lime transfer air blower (pressure).

[2] Includes lime slurry tank agitator; lime feeder; lime slaker; seal water filter; and lime slurry tank.

[3] Includes structures; fire protection; buildings; foundations, paving, and miscellaneous; sewers; and site development and miscellaneous.

INCREMENTAL CAPITAL COSTS FOR ENGINEERING ALTERNATIVE 6
(Treat slurry and construct lined cooling pond)
(in $ thousands)

UNIT	C-/D+	TOTAL
STACK LEACHATE/RUNOFF POND		
Rural Land Acquisition	38.7	
Site Preparation	470.4	
Excavation	308.5	
Perimeter Road	8.7	
Synthetic Liner	2,070.9	
Clay Liner, 3 ft., 20 mi.	7,461.1	
Waste Analysis	5.0	
Runon/off Control	324.9	
Site Security	268.5	
Ground-Water Monitoring Wells	86.1	
Subtotal		11,042.8
TOTAL		43,345.8

APPENDIX B6

Construct a new, lined cooling pond and lined stack leachate collection pond, and lime treat the gypsum slurry.

INCREMENTAL CLOSURE AND POST-CLOSURE COSTS FOR ENGINEERING ALTERNATIVE 5B
(Construct lined stack and recover FSA/treat cooling water)
(in $ Thousands)

MANAGEMENT UNIT	C-	TOTAL	D+	TOTAL
LINED GYPSUM STACK				
Closure				
Clay Liner, 3 ft., 20 mi.	972.9		0.0	
Sand Liner, 1 ft., 20 mi.	329.7		0.0	
Synthetic Liner	283.9		0.0	
Geotech Liner	106.0		0.0	
Topsoil and Grass	1,687.0		0.0	
Equipment Decontamination	0.4		0.0	
Superv. & Certification	6.4		6.4	
Subtotal		3,386.3		6.4
Post-Closure				
Leach Collection System Maint.	294.0		125.3	
Leachate Treatment	80.1		69.7	
Runon/off Controls	2.9		2.6	
Site Security	16.9		15.6	
Ground-Water Monitoring Wells	7.8		7.1	
Ground-Water Monitoring Analyses	222.4		205.1	
Mowing and Fertilizing	973.7		0.0	
Inspection/Reporting/Recordkeeping	2.5		2.5	
Subtotal		1,600.3		427.9
STACK LEACHATE/RUNOFF POND (C-/D+)			Same costs as C- scenario	
Closure				
Topsoil and Grass	406.4			
Supervision and Certification	6.4			
Equipment Decontamination	0.4			
Subtotal		413.2		413.2

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INCREMENTAL OPERATING AND MAINTENANCE AND OTHER ANNUAL COSTS FOR ENGINEERING ALTERNATIVE 5B
(Construct lined stack and recover FSA (double-stage)/treat cooling water)
(in $ thousands)

UNIT	C-	TOTAL	D+	TOTAL
COOLING POND EXPANSION - ADDITIONAL 50 ACRES			Same costs as C- scenario	
Labor: Operating (150-acre cooling pond)	218.0			
(Credit for current 100-acre cooling pond)	(218.0)			
Maintenance (150-acre cooling pond)	87.6			
(Credit for current 100-acre cooling pond)	(71.4)			
Utilities and Other Miscellaneous Costs (150-acre cooling pond)	150.0			
(Credit for current 100-acre cooling pond)	(99.4)			
Perimeter Road (150-acre cooling pond)	1.1			
(Credit for current 100-acre cooling pond)	(0.9)			
G-W Monitoring Wells Maint. (150-acre cooling pond)	0.9			
(Credit for current 100-acre cooling pond)	(0.7)			
Ground-Water Monitoring Analysis (150-acre cooling pond)	60.1			
(Credit for current 100-acre cooling pond)	(50.6)			
Property Tax & Insurance (150-acre cooling pond)	43.0			
(Credit for current 100-acre cooling pond)	(30.0)			
Subtotal		**89.7**		**89.7**
LINED GYPSUM STACK				
Labor: Operating	25.9		25.8	
Maintenance	7.4		7.4	
Utilities and Other Miscellaneous Costs	122.4		101.6	
Dredging Equipment	309.8		309.8	
Perimeter Road	1.1		1.0	
Leachate Collection	294.0		125.3	
Leachate Treatment	80.1		69.7	
Run-on/off Control	2.9		2.6	
Site Security	16.9		15.6	
Ground-Water Monitoring Well Maintenance	7.8		7.1	
Ground-Water Monitoring Analysis	222.4		205.1	
Property Tax & Insurance	1,679.7		1,001.4	
Financial Assurance	74.7		6.4	
Subtotal		**2,845.1**		**1,878.8**

INCREMENTAL OPERATING AND MAINTENANCE AND OTHER ANNUAL COSTS FOR ENGINEERING ALTERNATIVE 5B
(Construct lined stack and recover FSA (double-stage)/treat cooling water)
(in $ thousands)

UNIT	C-	TOTAL	D+	TOTAL
ACID LOSSES			Same costs as C- scenario	
Additional Sulfuric Acid Needed	138.0			
Production Loss from Scaling	3786.5			
Production Loss to Reduced Filter Efficiency	113.6			
Subtotal		**4,038.1**		**4,038.1**
PERMITS AND ENVIRONMENTAL IMPAIRMENT LIABILITY INSURANCE		**337.0**	Same costs as C- scenario	**234.3**
FSA SALES CREDIT		**(3,066.0)**	Same costs as C- scenario	**(3,066.0)**
TOTAL		**7,996.2**		**6,927.2**

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INCREMENTAL CAPITAL COSTS FOR ENGINEERING ALTERNATIVE 5B
(Construct lined stack and recover FSA/treat cooling water)
(in $ thousands)

UNIT	C-	TOTAL	D+	TOTAL
COOLING POND EXPANSION - ADDITIONAL 50 ACRES			Same costs as C- scenario	
Rural Land Acquisition (150-acre pond)	104.6			
(Credit for Current 100-acre pond)	(71.7)			
Site Preparation (150-acre pond)	1,161.7			
(Credit for Current 100-acre pond)	(823.5)			
Excavation (150-acre pond)	851.9			
(Credit for Current 100-acre pond)	(580.4)			
Perimeter Road (150-acre pond)	14.2			
(Credit for Current 100-acre pond)	(11.9)			
G-W Monitoring Well (150-acre pond)	17.6			
(Credit for Current 100-acre pond)	(14.8)			
Subtotal		647.7		647.7
LINED GYPSUM STACK				
Rural Land Acquisition	164.5		138.3	
Site Preparation	1,754.8		1,498.1	
Perimeter Road	14.7		13.6	
Synthetic Liner	16,329.9		6,926.0	
Geotech Liner	6,572.5		2,777.3	
Clay Liner, 3 ft, 20 mi	30,957.9		26,082.2	
Sand Liner, 1 ft, 20 mi	20,813.9		8,768.8	
Leachate Collection	5,938.3		2,532.0	
Slurry Pipeline .5 km.	21.2		21.2	
Waste Analysis	5.0		5.0	
Dredging Equipment	197.1		197.1	
Runon/off Controls	716.4		653.1	
Site Security	342.2		315.2	
Ground-Water Monitoring Wells	156.8		144.3	
Subtotal		83,985.2		50,072.2
TOTAL		106,734.4		72,821.4

INCREMENTAL OPERATING AND MAINTENANCE AND OTHER ANNUAL COSTS FOR ENGINEERING ALTERNATIVE 5B
(Construct lined stack and recover FSA (double-stage)/treat cooling water)
(in $ thousands)

UNIT	C-	TOTAL	D+	TOTAL
LIME TREATMENT			Same costs as C- scenario	
Variable Costs				
Raw Materials	1,495.0			
Labor: Operating	62.0			
Supervisor	9.0			
Maintenance/Repair	41.0			
Utilities: Electricity	41.0			
Operating Supplies	6.0			
Laboratory Services	9.0			
Subtotal		1,663.0		
Overhead Costs				
Administrative	25.0			
Property Tax & Insurance	59.3			
Subtotal		84.3		
Subtotal for Lime Treatment		1,747.3		1,747.3
FSA RECOVERY			Same costs as C- scenario	
Double-Stage FSA Recovery Units				
(Reaction and Evaporation)				
Labor: Operating and Maintenance	160.6			
Maintenance Materials	394.2			
Utilities: Electricity	255.6			
Laboratory Services	65.8			
Property Tax & Insurance	157.4			
Subtotal		1,033.6		1,033.6
CaF_2 SLUDGE DISPOSAL IMPOUNDMENT			Same costs as C- scenario	
Labor: Operating	218.0			
Maintenance	18.0			
Utilities and Other Miscellaneous Costs	6.4			
Perimeter Road	0.3			
Property Tax & Insurance	4.0			
Subtotal		246.7		246.7
STACK LEACHATE/RUNOFF POND (C-/D+)			Same costs as C- scenario	
Labor: Operating	261.7			
Maintenance	50.7			
Utilities and Other Miscellaneous Costs	50.0			
Perimeter Road	0.7			
Run-on/off Control	1.3			
Site Security	13.3			
Ground-Water Monitoring Well Maintenance	4.3			
Ground-Water Monitoring Analysis	115.6			
Property Tax & Insurance	220.9			
Financial Assurance	6.2			
Subtotal		724.7		

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INCREMENTAL CAPITAL COSTS FOR ENGINEERING ALTERNATIVE 5B
(Construct lined stack and recover FSA/treat cooling water)
(in $ thousands)

UNIT	C-	TOTAL	D+	TOTAL
LIME TREATMENT			Same costs as C- scenario	
Lime Receiving and Slaking				
Lime Pneumatic Car Unloading System[1]	128.6			
Lime Storage Bin with Activator	99.1			
Lime Slaking System[2]	158.5			
Lime Slurry Transfer Pump (to gypsum tank)	10.0			
Cooling Pond Lime Pump (to neutralization mixing basin)	18.7			
Lime Slurry Piping	24.0			
Subtotal		438.9		
Neutralization Mixing Basin				
Concrete Basin with HDPE Liner	131.0			
Mixing Basin Piping	200.0			
Jet Mixing Recirculating Pump	180.0			
Subtotal		511.0		
Associated Items				
Piping	195.0			
Electrical	68.0			
Instrumentation	107.0			
Civil Works[3]	97.0			
Insulation and Painting	19.0			
Subtotal		486.0		
Construction				
Labor	965.0			
Management	138.0			
Overhead	448.0			
Subtotal		1,551.0		
Subtotal for Lime Treatment		**2,986.9**		**2,986.9**

[1] Includes rail car flexible connector; lime unloading receiver, dust collector; receiver air lock; unloading air blower (vacuum), lime transfer air blower (pressure).

[2] Includes lime slurry tank agitator; lime feeder; lime slaker; seal water filter; and lime slurry tank.

[3] Includes structures; fire protection; buildings; foundations, paving, and miscellaneous; sewers; and site development and miscellaneous.

INCREMENTAL CAPITAL COSTS FOR ENGINEERING ALTERNATIVE 5B (Construct lined stack and recover FSA/treat cooling water) (in $ thousands)				
UNIT	C-	TOTAL	D+	TOTAL
FSA RECOVERY			Same costs	
Double-Stage FSA Recovery Units			as C-	
(Reaction and Evaporation)			scenario	
Vessels and Tanks[4]	1922.0			
Pumps[5]	127.2			
Subtotal		2,049.2		
Associated Items				
Piping	1374.2			
Electrical	42.2			
Instrumentation	29.8			
Structures	580.2			
Foundations, Paving, and Miscellaneous	179.4			
Painting	5.8			
Subtotal		2,211.6		
Construction				
Labor	2,126.4			
Management	303.8			
Overhead	1181.0			
Subtotal		3,611.2		
Subtotal for FSA Recovery		**7,872.0**		**7,872.0**
CaF_2 SLUDGE DISPOSAL IMPOUNDMENT			Same costs	
Rural Land Acquisition	7.3		as C-	
Site Preparation	102.5		scenario	
Excavation	86.5			
Perimeter Road	3.5			
Subtotal		**199.8**		**199.8**
STACK LEACHATE/RUNOFF POND (C-/D+)			Same costs	
Rural Land Acquisition	38.7		as C-	
Site Preparation	470.4		scenario	
Excavation	308.5			
Perimeter Road	8.7			
Synthetic Liner	2,070.9			
Clay Liner, 3 ft. 20 mi.	7,461.1			
Waste Analysis	5.0			
Runon/off Controls	324.9			
Site Security	268.5			
Ground-Water Monitoring Wells	86.1			
Subtotal		**11,042.8**		**11,042.8**

[4] Includes reactor first-stage FSA; recovery vessel; reactor FSA recirculation tank; first-stage evaporator FSA recircul[illegible] second-stage evaporator first-stage FSA recovery vessel; and second-stage evaporator FSA recirculation tank.

[5] Includes reactor FSA recirculation pump; first-stage evaporator FSA recirculation pump; and second-stage evapor[illegible] recirculation pump.

federal register

Thursday
June 13, 1991

Part II

Environmental Protection Agency

40 CFR Part 261

Special Wastes From Mineral Processing (Mining Waste Exclusion); Final Regulatory Determination and Final Rule

ENVIRONMENTAL PROTECTION AGENCY

[EPA/OSW-FR-91-018; FRL-3956-1]

40 CFR Part 261

RIN 2050-AC41

Final Regulatory Determination for Special Wastes From Mineral Processing (Mining Waste Exclusion)

AGENCY: Environmental Protection Agency.

ACTION: Final regulatory determination and final rule.

SUMMARY: Today's action presents the Agency's final regulatory determination required by section 3001(b)(3)(C) of the Resource Conservation and Recovery Act (RCRA) for 20 special wastes from the processing of ores and minerals. EPA has concluded that regulation under Subtitle C of RCRA is inappropriate for all 20 of the special wastes that were studied. EPA plans to address 18 of the wastes under subtitle D, possibly in the program being developed for mining wastes. For the remaining two wastes (phosphogypsum and process waste water from phosphoric acid production), EPA plans to proceed with the development and promulgation of a program under the Toxic Substances Control Act (TSCA) that will address their management, including possible regulations concerning waste minimization/pollution prevention for these wastes. In addition, EPA plans to use existing authorities under either RCRA Section 7003 or CERCLA section 106 to address any site-specific ground-water contamination problems that are believed to pose substantial and imminent endangerment to human health or the environment. EPA has also decided to postpone consideration of a possible ban on the utilization of one of the special wastes, slag from elemental phosphorus production in construction and/or land reclamation.

The rationale and salient facts used by the Agency to arrive at these decisions are provided below.

EFFECTIVE DATE: July 15, 1991.

FOR FURTHER INFORMATION CONTACT: For further information on the regulatory determination, contact the RCRA/Superfund hotline at (800) 424-9346 (toll free) or (703) 928-9810, or Bob Hall at (703) 308-8412.

SUPPLEMENTARY INFORMATION:

Table of Contents

I. Background

A. Statutory Authority

Today's notice is issued under the authority of section 3001(b)(3)(C) of RCRA, which requires that after completion of the Report to Congress mandated by section 8002(p) of RCRA, the Administrator must determine whether or not subtitle C regulation of the special study wastes is warranted. Wastes for which the exclusion is retained will continue to be subject to regulation under RCRA Subtitle D as solid wastes.

B. History of the Mining Waste Exclusion

In October, 1980, RCRA was amended by adding section 3001(b)(3)(A)(ii) to exclude "solid waste from the extraction, beneficiation, and processing of ores and minerals" from regulation as hazardous waste under subtitle C of RCRA, pending completion of a study and a Report to Congress required by section 8002 (f) and (p) and a determination by the EPA Administrator either to promulgate regulations under subtitle C or that such regulations are unwarranted and that the exclusion should continue (as required by section 3001(b)(3)(C)). EPA modified its hazardous waste regulations in November 1980 to reflect this "Mining Waste Exclusion," and issued a preliminary, and quite broad, interpretation of the scope of its coverage. In particular, EPA interpreted the exclusion to include "solid waste from the exploration, mining, milling, smelting and refining of ores and minerals" (45 FR 76618, November 19, 1980).

In 1984, EPA was sued for failing to submit the Report to Congress and make the required regulatory determination by the statutory deadline (*Concerned Citizens of Adamstown* v. *EPA* No. 84-3041, D.D.C., August 21, 1985). In responding to this lawsuit, the Agency explained that it planned to propose a narrower interpretation of the scope of the Mining Waste Exclusion, so that it would encompass fewer wastes, and proposed to the Court two schedules: One for completing the section 8002 studies of extraction and beneficiation wastes and submitting the Report to Congress addressing these wastes, and one for proposing and promulgating a reinterpretation for mineral processing wastes. In so doing, the Agency, in effect, split the wastes that might be eligible for exclusion from regulation into two groups: Mining (mineral extraction and beneficiation) wastes, and mineral processing wastes. The Court agreed to this approach and established a schedule for the two tasks.

On December 31, 1985, EPA published the required Report to Congress on solid wastes from mineral extraction and beneficiation, and on July 3, 1986 (51 FR 24496) published a determination that regulation of such wastes under subtitle C of RCRA was not warranted. Since the determination was made, the Agency has been developing a tailored regulatory approach for these wastes under RCRA subtitle D.

In keeping with its Court-ordered directive to reinterpret the Mining Waste Exclusion for mineral processing wastes, in October, 1985, EPA proposed to narrow the scope of the Exclusion for mineral processing wastes to include only a few specific waste streams (see 50 FR 40292, October 2, 1985). However, the Agency did not specify the criteria that it used to identify these wastes, or to distinguish them from other wastes that were not identified as being eligible for the exclusion. In response to this proposal, many companies and industry organizations "nominated" wastes that they believed were eligible for the regulatory exemption. Faced with an inability at that time to articulate criteria that could be used to distinguish exempt from non-exempt wastes and the approaching Court-ordered deadline for final action, EPA withdrew its proposal on October 9, 1986 (51 FR 36233).

In July, 1988, the court in *Environmental Defense Fund* v. *EPA*, 852 F.2d 1316 (D. C. Cir. 1988), *cert. denied*, 109 S. Ct. 1120 (1989) held that EPA's withdrawal of its 1985 proposal was arbitrary and capricious, and ordered EPA to reinterpret the scope of the Exclusion for mineral processing wastes. In particular, EPA was directed by the court to restrict the scope of the Exclusion as it applied to mineral processing wastes to include only "large volume, low hazard" wastes. In a series of rulemaking notices, EPA has, during the past three years, established the

boundaries of the Mining Waste Exclusion for mineral processing wastes, has articulated the criteria that were used to define "mineral processing," and has evaluated whether individual wastes are large volume and low hazard and, thus, eligible for the temporary exclusion provided by RCRA section 3001(b)(3)(A)(ii). This rulemaking process was completed with the publication of final rules on September 1, 1989 (54 FR 36592) and January 23, 1990 (55 FR 2322). With the completion of these notices, the Agency established that the temporary exemption from subtitle C requirements established by the Exclusion for mineral processing wastes and, therefore, the scope of the Report to Congress, was limited to 20 specific mineral processing wastes.

EPA then prepared and submitted a detailed and comprehensive Report to Congress addressing the 20 special mineral processing wastes, in compliance with the Court-ordered deadline. In addition to the explicit consideration of the eight study factors listed at section 8002(p) of RCRA, the Agency included in the Report a proposed regulatory status for each of the 20 special wastes. Thus, the Report serves both as an information source and as a tentative indication of the Agency's final determination. Accordingly, and in compliance with statutory directive, the Report, the data and analyses that underlie it, and the comments received on it have served as the primary basis for the regulatory decisions that are articulated in today's notice.

EPA did not complete the regulatory determination within the six month statutory deadline. As a result, the Environmental Defense Fund filed a new RCRA citizen's suit, which was settled by consent decree. *EDF* v. *EPA*, No. 91-0429 (D.D.C. Mar. 4, 1991). Under the terms of the consent decree, EPA must issue the regulatory determination no later than May 20, 1991. Today's decision is issued in compliance with that decree.

C. Overview of the Report to Congress

1. Scope of the Report

The scope of the Report to Congress was limited to 20 mineral processing wastes, representing 12 mineral commodity sectors. These wastes are generated by 91 facilities located in 29 states. The 20 wastes covered by the Report to Congress, organized by sector, follow:

Sector	Waste(s)
Alumina	Red and brown muds from bauxite refining.
Chromium (Sodium Chromate/ dichromate).	Treated residue from roasting/ leaching of chrome ore.
Coal gasification	Gasifier ash from coal gasification.
	Process wastewater from coal gasification.
Copper	Slag from primary processing.
	Calcium sulfate wastewater treatment plant sludge from primary processing.
	Slag tailings from primary processing.
Elemental Phosphorus.	Slag from primary production.
Ferrous Metals	Iron blast furnace APC dust/ sludge.
	Iron blast furnace slag.
	Basic oxygen furnace and open hearth furnace APC dust/sludge.
	Basic oxygen furnace and open hearth furnace slag.
Hydrofluoric acid	Fluorogypsum.
	Process wastewater.
Lead	Slag from primary processing.
Magnesium	Process wastewater from primary magnesium processing by the anhydrous process.
Phosphoric acid	Phosphogypsum.
	Process wastewater.
Titanium tetrachloride.	Chloride process waste solids.
Zinc	Slag from primary processing.

2. Study Factors

The RTC addressed the following eight study factors required by section 8002(p) of RCRA:

1. The sources and volumes of such materials generated per year;
2. Present disposal and utilization practices;
3. Potential danger to human health and the environment from the disposal and reuse of such materials;
4. Documented cases in which danger to human health or the environment has been proved;
5. Alternatives to current disposal methods;
6. The costs of such alternatives;
7. The impacts of these alternatives on the use of phosphate rock, uranium ore, and other natural resources; and
8. The current and potential utilization of such materials.

In addition, the statute suggests that the Administrator may review studies and other actions of other federal and state agencies, and invite participation by other concerned parties, including industry and other federal and state agencies, with a view toward avoiding duplication of effort.

The Agency's approach in preparing this Report was to combine certain study factors, for purposes of analysis and exposition, into seven sections. The first section provides a brief overview of the industry, including the types of production processes used and the number and location of operating facilities that generate one or more of the mineral processing special wastes. The second section summarizes information on waste characteristics, generation, and current management practices (study factors 1 and 2), while the third section provides a discussion of potential for and documented cases of danger to human health or the environment (study factors 3 and 4). The fourth section (as suggested generally by section 8002(p) of RCRA), summarizes applicable federal and state regulatory controls. The fifth section discusses alternative waste management practices and potential utilization of the wastes (study factors 5 and 8), while the sixth section discusses costs and impacts of alternative practices (study factors 6 and 7). The seventh and final section summarizes and analyzes the findings of EPA's evaluation of the above study factors.

3. Preliminary Findings in the Report to Congress

The Report to Congress presented EPA's preliminary findings regarding the 20 special wastes from mineral processing, based on two separate approaches: (1) The application of the RCRA section 8002(p) study factors and (2) the application of the RCRA section 8002(p) study factors and additional considerations. A summary of the Agency's findings, prior to receipt and analysis of public comments, regarding the appropriate regulatory status of the 20 mineral processing special wastes covered in the RTC is provided below.

REPORT TO CONGRESS TENTATIVE RECOMMENDATIONS [1]

Waste stream	Approach 1 (using 8002(p) study factors)		Approach 2 (using 8002(p) study factors and additional considerations)
	Full subtitle C	Subtitle C-minus	
Red and Brown Muds from Bauxite Refining	D	D	D
Treated Residue from Roasting/Leaching of Chrome Ore	D	D	D
Gasifier Ash from Coal Gasification	D	D	D
Process Wastewater from Coal Gasification	D	D	D
Slag from Primary Copper Processing	D	D	D
Slag Tailings from Primary Copper Processing	D	D	D
Slag from Elemental Phosphorus Production	D	D	D
Iron Blast Furnace Slag	D	D	D
Basic Oxygen Furnace and Open Hearth Furnace Slag from Carbon Steel Prod.	D	D	D
Fluorogypsum from Hydrofluoric (HF) Acid Production	D	D	D
Process Wastewater from Magnesium Processing	D	D	D
Slag from Primary Zinc Processing	D	D	D
Phosphogypsum from Phosphoric Acid Production	D	D	D
Process Wastewater from Phosphoric Acid Production	D	D	D
Air Pollution Control Dust/Sludge from Iron Blast Furnaces	D	D	D
Air Pollution Control Dust/Sludge from Basic Oxygen Furnaces and Open Hearth Furnaces from Carbon Steel Production	D	D	D
Slag from Primary Lead Processing	D	C	D
Calcium Sulfate Wastewater Treatment Plant Sludge from Primary Copper Processing	D	C	D
Process Wastewater from HF Acid Production	C	C	D
Chloride Process Waste Solids from Titanium Tetrachloride Production	D	C	D

[1] Source: USEPA. 1990. Report to Congress on Special Wastes from Mineral Processing, Vol. I, pp. 11–17.

a. Approach 1: Application of the RCRA Section 8002(p) Study Factors

1. Wastes EPA Tentatively Recommended to Remain Under RCRA Subtitle D

Using the study factors listed in RCRA section 8002(p), EPA examined: (1) The potential for and documented danger to human health and the environment; (2) the need for additional regulations; and (3) the costs and impacts of subtitle C regulation for the 20 special wastes. EPA's analysis did not merely evaluate whether the wastes should be treated as hazardous in light of the criteria under subtitle C for other wastes, but took into account Congress' desire to examine "special wastes" in a different light. EPA's analysis suggested that regulation under subtitle C of RCRA would be inappropriate for the following 16 mineral processing wastes:

- Red and brown muds from bauxite refining;
- Treated residue from roasting/leaching of chrome ore;
- Gasifier ash from coal gasification;
- Process wastewater from coal gasification;
- Slag from primary copper processing;
- Slag tailings from primary copper processing;
- Slag from elemental phosphorus production;
- Iron blast furnace slag;
- Basic oxygen furnace and open hearth furnace slag from carbon steel production;
- Air pollution control dust/sludge from iron blast furnaces;
- Air pollution control dust/sludge from basic oxygen furnaces and open hearth furnaces from carbon steel production;
- Fluorogypsum from hydrofluoric acid production;
- Process wastewater from primary magnesium processing by the anhydrous process;
- Process wastewater from phosphoric acid production;
- Phosphogypsum from phosphoric acid production; and
- Slag from primary zinc processing.

Three of these sixteen wastes (treated residue from roasting/leaching of chrome ore; process wastewater from coal gasification; and slag tailings from primary copper processing) were found not to pose an actual or potential danger to human health and the environment. The thirteen remaining wastes were identified as having some actual or potential hazard associated with current management practices or plausible mismanagement scenarios, and so were further evaluated.

EPA found that the potential risk associated with slag from primary zinc processing, process wastewater from primary magnesium processing by the anhydrous process, air pollution control (APC) dust/sludge from iron blast furnaces and from basic oxygen and open hearth furnaces used to make carbon steel, red and brown muds from bauxite refining, elemental phosphorus slag, and gasifier ash from coal gasification, was comparatively low; that is, the Agency found that management of these materials did not present a substantial hazard to human health or the environment. In particular, no documented damages attributable to these wastes were identified. In addition, State regulations are in effect for the one primary magnesium facility and revised/strengthened regulations have been proposed for the primary zinc processing facility. EPA also found that several facilities recycle rather than dispose of ferrous metal production APC dust. Therefore, the Agency found that subtitle C regulation was not appropriate. In the case of elemental phosphorus slag, the Agency found that while there appeared to be some significant hazards associated with use of the material in construction applications (that is, off-site utilization), the best means of dealing with this problem was through the use of authorities provided by RCRA section 3001(b)(3)(B)(iii) (which allows for special controls from phosphate rock mining and mineral processing wastes) rather than through imposition of the subtitle C hazardous waste management standards.

EPA identified four wastes that did not exhibit a hazardous characteristic (with the exception of one sample of copper slag at one facility) but for which documented cases of adverse environmental impacts that affected surface water were identified at at least one facility:

- Iron blast furnace slag;
- Slag from primary copper processing;
- Basic oxygen furnace and open hearth furnace slag from carbon steel production; and
- Fluorogypsum from hydrofluoric acid production.

For all four wastes, however, these surface water releases (one of which occurred via ground water) have been and/or are being addressed under existing regulatory authorities at the state and/or federal level. Therefore, the Agency concluded that regulation of these four wastes as hazardous would not provide additional protection to human health or the environment justifying the elimination of the special status of these wastes; thus, subtitle C regulation was not considered appropriate.

Phosphogypsum and phosphoric acid process wastewater were also of concern because damage case information indicated that both closed and currently active phosphogypsum stacks (in which both the phosphogypsum and the wastewater are managed) and wastewater cooling ponds have caused ground-water contamination at 15 of the 16 facilities for which monitoring data are available. The available waste composition data indicated that phosphogypsum tested EP toxic at one of the ten facilities with available data, and process wastewater exhibited the characteristic of corrosivity at most facilities and the EP-toxicity characteristic at some facilities. However, EPA also estimated that the total industry-wide, incremental annualized cost of either full subtitle C regulation or the Subtitle C-Minus scenario [1,2] for phosphogypsum and process wastewater, as compared to the Subtitle D-Plus scenario [3] developed for cost estimating purposes, could exceed $500 million and $50 million respectively, and could significantly affect several facilities. The Report estimated that economic impacts associated with subtitle C or C-Minus regulation at these facilities were expected to be significant, and it was unlikely that these facilities could pass along their higher costs. As a result, EPA tentatively concluded that regulation for these wastes was most appropriate under RCRA subtitle D.

2. Wastes EPA Tentatively Considered for Regulation Under RCRA Subtitle C or D

EPA found, based on the information available at that time, that the remaining four wastes (calcium sulfate wastewater treatment plant sludge from primary copper processing, slag from primary lead processing, process wastewater from hydrofluoric acid production, and chloride process waste solids from titanium tetrachloride production) have posed or may pose a danger to human health or the environment. Available data indicated that all four of the wastes exhibit one or more of the characteristics of hazardous wastes. In particular, EPA found that all of the wastes except process wastewater from hydrofluoric acid production exhibit the characteristic of EP toxicity at at least one facility; process wastewater from hydrofluoric acid production was found to be corrosive at all facilities where it is generated. In addition, damages associated with these wastes were documented as follows: (1) Current lead slag management practices have resulted in surface water contamination; (2) ground-water contamination that may in part be attributable to calcium sulfate sludge from primary copper processing was found at one of the two facilities that generate the waste; and (3) ground-water contamination that may in part be attributable to chloride process waste solids from titanium tetrachloride production was identified at at least one facility that generates this waste. Furthermore, the Report stated that the Agency was not confident that current practices and regulations are adequate to prevent further danger to health or the environment from these four wastes.

Nevertheless, EPA tentatively concluded that regulation of three of the four wastes as hazardous (calcium sulfate wastewater treatment plant sludge from primary copper processing, slag from primary lead processing, and chloride process waste solids from titanium tetrachloride production), under full subtitle C was not appropriate due to cost considerations. The Agency's basis for this finding was a cost comparison between full subtitle C and the D-Plus scenario (with Subtitle D-Plus including subtitle D requirements similar to those being developed for extraction and beneficiation wastes) that showed that the costs for full subtitle C regulation would be significantly higher and the associated impacts would be more significant at nearly all facilities than the estimated costs of regulation under the Subtitle D-Plus scenario.

For process wastewater from hydrofluoric acid production, EPA found that the estimated compliance costs for regulation under full subtitle C and regulation under the Subtitle D-Plus scenario were comparable and that the likely economic impacts were not expected to be significant. Based on these factors, EPA tentatively concluded that process wastewater from hydrofluoric acid production may warrant regulation under subtitle C.

On the other hand, EPA also estimated the cost of managing these four wastes under a subtitle C scenario that utilizes the flexibility provided by RCRA section 3004(x) (Subtitle C-Minus).[4] The Agency then compared the costs for Subtitle C-Minus regulation (rather than full subtitle C regulation) to the estimated costs that might result from regulation under a subtitle D program similar to those being developed for extraction and beneficiation wastes (Subtitle D-Plus). EPA found that the estimated costs for the Subtitle C-Minus and Subtitle D-Plus scenarios are comparable for nearly all facilities. Assuming a Subtitle C-Minus scenario, EPA tentatively concluded that all four wastes might warrant regulation under subtitle C.

b. Approach 2: Application of the RCRA Section 8002(p) Study Factors and Additional Considerations

Sections 3001(b)(3) and 8002(p) of RCRA and the decision in *Environmental Defense Fund* v. *EPA*, 852 F.2d 1309 (D.C. Cir. 1988) make it clear that the Agency may and should consider the specific factors of section 8002(p) (1)–(8) in making its decision regarding the appropriate regulatory status of special wastes. In addition, the Agency stated in the Report that in making its regulatory determination, it might be appropriate to consider other factors relating to the broader goals and objectives of the Agency and RCRA, such as developing and maintaining strong state mining and mineral processing waste regulatory programs and facilitating implementation of federal programs.

Accordingly, EPA stated in the Report to Congress that in order to facilitate both development and maintenance of strong state programs and implementation of any federal regulations that may be necessary for mineral processing wastes, it might be

[1,2] A subtitle C scenario that utilizes the flexibility provided by RCRA section 3004(x).

[3] A subtitle D program similar to those being developed for extraction and beneficiation wastes.

[4] The Subtitle C-Minus scenario that was considered in the RTC is hypothetical and was assumed only for the purpose of cost estimation; it does not necessarily represent what EPA would consider an appropriate regulatory program.

appropriate to regulate all 20 of the special wastes under subtitle D of RCRA. In addition, the Report stated that some mining and mineral processing wastes might be excluded from any further federal regulation under RCRA.

In light of these considerations, the results of Approach 2 indicated that it might be appropriate for the waste streams identified under Approach 1 for potential subtitle C (full C or C-Minus) regulation not be subject to the hazardous waste management standards, but instead to be retained within the Mining Waste Exclusion. If such a finding was appropriate, EPA stated that it would need to be conditioned on the premise that major steps be taken to control releases from the facilities generating these waste streams. Some corrective measures are already being taken under a variety of Agency authorities (e.g., RCRA, Superfund, CWA) and more can and would be undertaken. EPA also asserted that the states must act to address the most immediate problems posed by these wastes, as well as any of the other mineral processing special wastes that have been found in the Report to pose significant actual or potential hazard to human health or the environment. To assist in this effort, EPA pledged to provide technical and other resource support to the involved states to improve their programs. If near term actions did not result in adequate control of such wastes, EPA would then take action to reconsider its regulatory determination and could designate certain waste streams as subtitle C hazardous wastes.

4. Public Comment Process

With publication of the Report to Congress, EPA initially established a 60-day public comment period that ended on September 28, 1990. In response to requests from several commenters, however, EPA extended the comment period to October 19, 1990. In addition, a public hearing on the Report was held in Washington, DC on October 17, 1990. EPA received 91 sets of written comments prior to the close of the comment period and eight late comments. All individual comments and a transcript from the public hearing are available for public inspection in the docket (Docket No. F-90-RMPA-FFFFF). The docket also contains a summary of all the comments presented at the hearings or submitted in writing. EPA's responses to those comments are provided in the docket, as well as in appendix A to this regulatory determination.

D. Supplemental Analysis and Notice of Data Availability

Supplemental analyses were conducted on five wastes that were addressed in the Report to Congress, including gasifier ash and process wastewater from coal gasification, basic oxygen furnace and open hearth furnace air pollution control dust/sludge, and phosphogypsum and process wastewater from phosphoric acid production. A Notice of Data Availability (NODA), which announced the availability of this information, was published in the **Federal Register** on January 7, 1991.

A 30-day public comment period was provided, which closed on February 6, 1991. As in the case of the Report to Congress, EPA received requests that it extend the comment period. However, EPA did not extend this comment period because of the need to proceed with the regulatory determination process as expeditiously as possible and because the Agency believed that the comment period provided was adequate. In addition, EPA took steps to ensure that commenters could make the maximum use of the time available. For example, EPA made the supplemental data publicly available as soon as possible, immediately following Agency signature, rather than waiting until the NODA was published in the **Federal Register**. Also, at the request of industry, EPA delayed the start of the public comment period until after the holidays.

Included in the new data was information on phosphoric acid process wastewater and phosphogypsum concerning generation and management of these wastes, the engineering feasibility and cost of alternative waste management practices, waste characteristics, ground water monitoring data, and state regulations. The Agency specifically solicited comments on the engineering feasibility and accuracy of cost estimates for the alternative waste management practices presented as part of the new data.

The Agency received 22 written comments addressing the NODA. All of the comments are available for public inspection in Docket No. F-91-RM2A-FFFFF. Agency responses to the comments are provided in the docket and appendix B to this regulatory determination.

II. Factors Considered in Making the Regulatory Determination

The RCRA statute, as amended, directs EPA to make a regulatory determination for the special study wastes based upon its Report to Congress and comments received from interested parties. The statute contains the following eight study factors:

1. The sources and volumes of such materials generated per year;
2. Present disposal and utilization practices;
3. Potential danger, if any, to human health and the environment from disposal and reuse of such materials;
4. Documented cases in which danger to human health or the environment has been proved;
5. Alternatives to current disposal methods;
6. The costs of such alternatives;
7. The impact of those alternatives on the use of phosphate rock and uranium ore, and other natural resources; and
8. The current and potential utilization of such materials.

In addition, RCRA section 8002(p) suggests that EPA review studies and actions of other federal and state agencies, and invite participation from concerned parties, including industry and other federal and state agencies in an attempt to avoid duplication of effort.

EPA has complied with the Congressional mandate in developing the required Report to Congress and soliciting and incorporating comments received from affected parties. In making today's regulatory determination, the Agency has relied upon the analysis of the eight study factors described as "Approach 1" in the RTC, modified slightly in response to public comments. EPA believes that this approach is most consistent with Congressional intent. To the extent that the Agency were otherwise to conclude that subtitle C regulation was warranted based upon consideration of all of these factors and information, EPA believes, upon further reflection, that it is unnecessary and probably inappropriate to look outside the Report to Congress, public comments, and supplemental technical information, as outlined for Approach 2 in the RTC, to justify a different determination.

In addition, as discussed in more detail in appendix A to this preamble, EPA believes that the so-called "additional factors" upon which Approach 2 was based are, in large part, already embodied within the contours of the inquiry that Congress intended for EPA to make in the Report and regulatory determination. The Report identifies (1) the development and maintenance of strong state mining and mineral processing regulatory programs, and (2) the facilitation of an integrated federal mining regulatory program as the key considerations under Approach 2. Section 8002(p)(5) instructs EPA to consider "alternatives to current

disposal methods" as a factor in developing the Report and regulatory determination. Certainly, consideration of alternative state regulatory schemes, in addition to federal schemes, is contemplated by this section. Also, facilitation of a potential integrated federal mining program was actually considered by EPA in its cost estimates (reflected in the "Subtitle D-Plus scenario").

Nonetheless, EPA does not believe that it should rely on "possible" improved state programs to determine that subtitle C is not warranted unless EPA is confident that such programs are being developed and can address the problems associated with mineral processing wastes that may pose a significant risk. Thus, EPA believes that section 8002(p) requires that EPA not consider these factors in a way that would supplant any decision the Agency makes under the decision making methodology outlined in Approach 1.

In any event, EPA notes that the issue is effectively moot. As discussed below, EPA has determined, on the basis of Approach 1, that subtitle C is not appropriate for any of the 20 wastes analyzed. Thus, even if EPA were to employ Approach 2 as outlined in the Report, it would not change any of the decisions made today.

In "Approach 1," the Agency evaluated the RCRA section 8002(p) study factors by first assessing the need for additional regulatory controls (or absence thereof), then evaluating the options for appropriate requirements that could be applied to each individual waste stream for which additional controls might be in order, and, finally, estimating the associated costs and impacts. In applying the decision criteria, EPA believes that the factors that are most important in establishing the regulatory status of the special wastes should be given major emphasis. Therefore, potential risks posed and documented damages caused by the wastes, the need for additional regulations, and the costs and impacts that would be associated with more stringent regulatory controls are the focus of the three steps in the analytical process. The reason for this is that in the absence of a realistic showing of a potential risk and/or documented damages from current management (or in appropriate cases, plausible mismanagement), EPA believes that Congress would not intend to eliminate the special status of these wastes by imposing hazardous waste regulation under RCRA Subtitle C; if greater regulatory controls may be appropriate because of significant potential or documented danger, the costs and impacts of regulatory controls are the critical factors in determining whether a given alternative would conform to Congress' expressed goals for these wastes (adequate protection of human health and the environment and continued operation of the affected industries).

The overall decision making process as described in the RTC was left basically intact for the purpose of this regulatory determination. However, a number of specific changes have been made to the individual decision criteria in response to public comments; these changes are detailed below, and address the specific questions considered in this step-wise process, as well as how the answers to these questions interact when deciding whether to go from one step to the next.

The modified step-wise process that the Agency applied to the available information is outlined below.

Step 1. Does management of this waste pose human health/environmental problems? Might current practices cause problems in the future?

Critical to the Agency's decision making process is whether the special waste either has caused or may cause human health or environmental damage. To resolve these issues, EPA has posed the following key questions:

1. Has the waste, as currently managed, caused documented human health impacts or environmental damage?

2. Does EPA's analysis indicate that the waste may pose a significant risk to human health or the environment at any of the sites that generate it (or in off-site use), under either current management practices or plausible mismanagement scenarios?

3. Does the waste exhibit any of the characteristics of hazardous waste?

In the RTC, EPA concluded that further evaluation was necessary if the answer to any of these three questions was yes. However, numerous commenters argued that several of the damage cases included in the RTC do not represent today's conditions, for a variety of reasons, that the risk assessment conducted for the RTC tends to overstate risk, and that the leachate concentrations measured using the EP leach test overestimate actual leachate concentrations. Although EPA disagrees with many of the specific points made by commenters in support of these arguments, as discussed in appendix A to this preamble, the Agency believes that a more flexible decision making approach is warranted in response to the general concerns expressed.

Concluding that further evaluation is necessary if the answer to just one of the above questions is yes, without taking into account the overall certainty and conservativeness of that answer relative to the answers to the other questions, could unnecessarily lead the Agency into Step 2 of the decision making process.

Therefore, for this regulatory determination, EPA answered each of these questions and then considered the combined answers as a whole in deciding whether further evaluation was necessary. A fundamental concept in this approach was that no one question is more significant in reaching a decision regarding potential hazard than the others, as the answer to one question could offset, somewhat, the answer to another. That is, rather than following a very rigid approach of proceeding to Step 2 if the answer to just one question was yes, the Agency considered how the answers traded off, taking into account each answer's supporting weight of evidence and certainty.

For example, the scenario for a given waste could be that (1) there was not a documented damage case that could be attributed to the waste with reasonable certainty (i.e., the answer to question 1 was no); (2) the reasonably conservative risk analysis provided a sound basis for concluding that the potential for human health and environmental problems was low under current management practices or plausible mismanagement scenarios (i.e., the answer to question 2 was no); and (3) the waste exhibited the toxicity characteristic using the EP leach test (i.e., the answer to question 3 was yes), but only rarely and never for samples analyzed using the Synthetic Precipitation Leaching Procedure (SPLP). Under this scenario, EPA would have reached an overall low hazard conclusion because the balance of the information supporting the answers to questions 1 and 2 effectively outweighs, in the Agency's judgment, the answer to question 3.

By following this approach, the Agency considered all of the relevant information in making its decision on the potential for each waste to pose human health and environmental problems. If this analysis led the Agency to conclude that there is a reasonable potential for problems, then EPA concluded that further evaluation was necessary. If the conclusion was that the potential for problems is low, then the Agency determined that regulation of the waste under RCRA subtitle C is not appropriate. EPA believes that this "balancing" approach to the analysis in

Step 1 allows EPA to determine with more precision the actual hazards posed by those wastes, consistent with the intent of the Bevill Amendment. 852 F.2d at 1314. EPA also notes that this analysis does not precisely match the approach EPA uses to list or identify non-special wastes as hazardous, but is more conservative in the direction of not imposing regulation unless the potential risk justifies elimination of special status.

Step 2. Is more stringent regulation necessary and desirable?

If the waste has caused or may potentially cause human health or environmental impacts as determined in Step l, then EPA concluded that an examination of alternative regulatory controls was appropriate. Given the context and purpose of the study, the Agency focused on an evaluation of the likelihood that such impacts might continue or arise in the absence of more stringent regulation, and whether subtitle C would be an efficient mechanism for controlling these impacts. Specifically, the Agency posed three questions:

1. Are current practices adequate to limit contaminant release and associated risk?
2. Are current federal and state regulatory controls adequate to address the management of the waste?
3. Will Subtitle C effectively address problems associated with the waste without imposing significant unnecessary controls that are inconsistent with the special status of the waste?

Due to changes made in response to public comments, these questions differ from the questions presented for Step 2 in the RTC, in two ways. First, the Agency eliminated a question concerning the likelihood of new facilities opening in the future and generating and managing a special waste in a different environmental setting than those examined in the RTC. The Agency acknowledges that this is a relevant issue and considered it in the Report to Congress for each industry and waste that was studied. However, EPA agrees with public commenters that an analysis of this issue relies largely on conjecture about the potential conditions that might exist at a new facility, if one were to open. Therefore, the Agency believes that the potential for problems at hypothetical new facilities is less important than the other factors considered in the decision making process, and did not consider the question explicitly in developing the regulatory determination.

Second, several commenters argued that subtitle C regulation, even with Section 3004(x) flexibility, would impose numerous prescriptive standards that would not necessarily be needed to control the problems at a given facility or across a commodity sector. While EPA disagrees with many of the specific points made by these commenters in support of their arguments, as presented in the appendices to this preamble, the Agency agrees that the suitability of subtitle C controls relative to the magnitude and extent of the problem(s) defined in Step l is an important issue in the decision making process and the approach is also consistent with EPA's previous approach to making regulatory determinations under the Bevill Amendment, which focused on whether subtitle C, even with the use of Section 3004(x), might be too "cumbersome and uncertain" to accomplish the goals of effective regulation of the risks from special wastes, or put another way, whether subtitle C is the right "template" for regulating the special wastes at issue. 852 F.2d at 1313, 1315. Therefore, the Agency added the third question listed above for the purpose of developing today's regulatory determination.

EPA considered the answers developed for these questions together with the answers to the questions addressed in Step 1 to reach an overall conclusion on the need for further evaluation. If current practices or existing regulatory controls were found to be adequate, or Subtitle C would not be an effective regulatory alternative, and if the potential for actual future impacts was considered low (e.g., existing facilities in remote locations, low likelihood of actual risk, adequate federal or state regulatory controls already exist), then the Agency concluded that the waste should not be regulated under Subtitle C. Otherwise, further examination of regulatory alternatives was considered necessary.

Step 3. What would be the operational and economic consequences of a decision to regulate a special waste under Subtitle C?

If, based upon the previous two steps, EPA believed that a waste might be a candidate for regulation under subtitle C, then the Agency estimated and evaluated the costs and impacts of two regulatory alternatives that are based upon subtitle C, and one regulatory alternative that reflects one possible approach that might be taken under RCRA subtitle D ("Subtitle D-Plus"). Two evaluations were performed. The first focused on the magnitude, distribution, and significance of the incremental costs of regulation under full Subtitle C as compared to the Subtitle D-Plus scenario for each potentially affected facility. The second focused on incremental costs and impacts associated with regulation under a modified subtitle C ("Subtitle C-Minus") scenario, that incorporates waste management standards based upon site-specific risk potential, as compared to Subtitle D-Plus. The key questions in the Agency's decision making process for both comparisons were as follows:

1. Are predicted economic impacts associated with the full subtitle C (or Subtitle C-Minus in the case of the second comparison) scenario significant for any of the affected facilities?
2. Are these impacts substantially greater than those that would be experienced under the Subtitle D-Plus scenario?
3. What is the likely extent to which compliance costs could be passed through to product markets or input costs could be reduced, i.e., to what extent could regulatory cost burdens be shared?
4. In the event that costs are significant, could a large proportion of domestic capacity or product consumption be affected?
5. What effects would hazardous waste regulation have upon the viability of the beneficial use or recycling of the special waste?

In EPA's judgment, an ability to pass through costs or an absence of significant impacts suggested that subtitle C regulation (or Subtitle C-Minus in the case of the second comparison) might be appropriate for wastes that pose significant risk. In cases in which the subtitle C (or Subtitle C-Minus) scenario would impose widespread and significant impacts on facilities, result in reductions in domestic capacity or supply, and/or deter the safe and beneficial use of the waste, EPA concluded that regulation under some other regulatory authority, including Subtitle D or TSCA, might be more appropriate.

III. Regulatory Determination for the 20 Special Wastes From Mineral Processing

The following discussion presents EPA's conclusions regarding the appropriate regulatory status of each of the special wastes from mineral processing, based on information obtained by analyzing the statutory study factors in the manner outlined above. The information summarized here incorporates information received during the public comment period and additional refinement of the data

presented in EPA's July 1990 Report to Congress and January 1991 NODA.

EPA has decided that regulation under subtitle C is inappropriate for all 20 of the mineral processing wastes. For nine of the wastes, no comments were received that objected to EPA's tentative determination in the Report to Congress that regulation under subtitle C for these wastes is unwarranted. These nine wastes include:

(1) Red and brown muds from bauxite refining;
(2) Treated residue from roasting/leaching of chrome ore;
(3) Gasifier ash from coal gasification;
(4) Process wastewater from coal gasification;
(5) Fluorogypsum from hydrofluoric acid production;
(6) Iron blast furnace slag;
(7) Basic oxygen furnace and open hearth furnace slag from carbon steel production;
(8) Slag tailings from primary copper processing; and
(9) Process wastewater from primary magnesium processing by the anhydrous process.

For the remaining eleven wastes, EPA received at least one comment arguing that subtitle C regulations should be promulgated. EPA's determination rationale for each of these wastes follows.

Slag From Primary Copper Processing. An examination of available information regarding copper slag leads to the following findings regarding the three key questions outlined above for Step I in the Agency's decision making process.

First, copper slag rarely, if ever, exhibits a hazardous waste characteristic. Only one sample out of 70 exceeded EP-toxicity regulatory levels, for cadmium and lead. The Agency agrees with commenters that the accuracy of the one sample is questionable, because the cadmium concentrations in the EP leachate extract are inconsistently high compared to concentrations in the total sample analysis.

Second, although one commenter pointed out that the slag contains a number of constituents in concentrations that exceed the conservative risk screening criteria used in the Report to Congress, these concentrations by themselves do not demonstrate that the slag poses a significant hazard. An examination of the slag management practices and environmental conditions at the 10 active primary copper facilities indicates that copper slag currently generated at these facilities poses an overall low risk to human health and the environment. This is largely due to the fact that most of the active facilities are located in areas with low-risk environmental and exposure characteristics (e.g., very low precipitation and net recharge, large depths to ground water, large distances to surface water, and great distances to potentially exposed populations). As pointed out by several commenters, with whom EPA agrees, the Agency's risk modeling for copper slag was very conservative (tending to overestimate risks) and supports a conclusion that the slag poses low risks as currently managed.

Finally, following careful review of the information and public comments on the copper slag damage cases, EPA believes that the damages documented in the RTC for copper slag resulted from unusual circumstances that generally do not represent current management practices. For example, the damages at Commencement Bay (Puget Sound) were caused by the use of copper slag, as well as other wastes, as fill in a wetland or tideflats area. The nearby copper facility that generated the slag is now inactive, and the ten active primary copper processing facilities are generally concentrated in arid areas where it is very unlikely that slag could be disposed of in a wetland. Similarly, at the inactive copper facilities in Midvale, UT and El Paso, TX, environmental contamination has been caused by the co-management of slag from copper, lead, and/or zinc processing since the late 1800's. Based on the available damage case information, survey responses, and public comments, EPA believes that these cases do not reflect the industry norm today. In addition, EPA presently does not have damage case information that suggests that current copper slag management practices are causing problems.

Based on these findings, EPA concludes that current management of copper slag does not appear to pose significant human health or environmental hazards, and current slag management practices appear unlikely to cause problems in the future. As a result, Federal regulation under subtitle C is not appropriate. Given this finding, EPA did not evaluate the questions addressed in Steps 2 and 3 of the decision making methodology.

Slag From Elemental Phosphorus Production. Addressing the questions in Step 1 of the decision making process, the information included in the RTC and provided in public comments leads to the following major findings for elemental phosphorus slag.

First, elemental phosphorus slag does not exhibit any of the four characteristics of hazardous waste. One commenter contends that the slag is intrinsically dangerous because it is radioactive and contains toxic constituents. EPA agrees that the radionuclide content may pose a direct radiation threat when the slag is used off-site. (See further discussion on this issue later in this section and in section IV.) However, the slag contains few chemical constituents that exceed the RTC's conservative risk screening criteria by a significant margin, and none exceed regulatory levels that would qualify the slag for subtitle C controls.

Second, current on-site slag management practices and environmental conditions at the five active elemental phosphorus facilities generally pose a low risk via the ground-water and surface water exposure pathways. Significant risks via these pathways are limited by the low concentrations of potentially harmful constituents in slag leachate and the generally large size of slag particles that limit stormwater erosion potential. In addition, the potential for the slag piles to cause significant impacts to surface water is precluded by the relatively great distance (more than 500 meters) to the nearest water body at two facilities, the use of stormwater run-off controls at the slag piles at two facilities, and the large flow and assimilative capacity (30 cubic meters per second or 1,058 cubic feet per second) of the creek closest to the fifth facility. As the RTC and one commenter point out, one of the sites is located within a mile of a wetland, one site overlies an area of karst terrain, and one facility is located in a National Forest. While these facts are pertinent, the Agency believes, based on all the evidence, that existing management practices for elemental phosphorus slag should not significantly threaten these environments through the ground-water and surface water pathways, given the small potential for releases to these media.

Moreover, although one commenter points out that ground-water contamination has been observed at three of the five active facilities, available information on the documented damages at elemental phosphorus facilities indicates that the ground-water contamination is due to other wastes and waste management practices (e.g., historic unlined ponds used to store process wastewater). This supports the above finding that on-site management of the slag does not pose a significant ground-water risk.

On-site management at three facilities, however, may pose a

moderate risk via the air exposure pathway due to the chromium, cadmium, and uranium-238 concentrations in the slag. Although the vitrified nature and generally large size of particles tends to limit wind erosion, there is some evidence that dust from slag piles may be blown into the air and potentially lead to exposures. As noted in the RTC and reiterated by one commenter, three of the facilities are located in fairly densely populated areas and three are located in agricultural areas where airborne deposition and subsequent food chain exposures are possible.

Based on these findings, EPA concludes that current on-site management practices for elemental phosphorus slag do not appear to pose a significant ground-water or surface water risk and are not likely to cause significant problems through these pathways in the future. However, there is some potential for airborne releases and resulting impacts; because of the Agency's desire to fully evaluate all potential risks, the Agency proceeded to Step 2 of its decision making process to evaluate whether more stringent regulation is necessary and desirable.

In this step, EPA made three basic findings:

- The relatively low to moderate risk from the on-site management of elemental phosphorus slag is expected to continue in the future in the absence of subtitle C regulation given current waste management practices and environmental conditions at the five active facilities. The slag characteristics and existing management practices at the five active facilities are unlikely to change significantly.
- None of the states where elemental phosphorus slag is generated specifically apply fugitive dust control requirements to slag piles. However, adequate authority and mechanisms already exist under the Clean Air Act to control this dust. For example, the National Ambient Air Quality Standards include a standard for the airborne concentration of particulate matter, and the dust could be controlled under the National Emission Standards for Hazardous Air Pollutants, if necessary.
- Regulation under subtitle C would impose significant and specific requirements (e.g., liners, caps, ground-water monitoring) that are directed at controlling releases/risks that do not appear to exist or are otherwise controlled and, thus, are not appropriate given the special status of the waste.[6]

Based on these combined findings from Steps 1 and 2, EPA concludes that regulation of elemental phosphorus slag under subtitle C is not appropriate under the circumstances. (Accordingly, EPA did not proceed to Step 3 of its decision making process.) EPA plans to further examine the potential impacts of fugitive dust emissions from elemental phosphorus slag piles and will determine whether controls for these releases are needed, and if so, whether they can be developed under the Clean Air Act.

The Agency is uncertain about the potential gamma radiation exposures and risks associated with off-site use of elemental phosphorus slag in construction and land reclamation. As discussed in more detail in section IV of this preamble, the Agency has postponed any decisions about the significance of this risk and the need for additional control of off-site uses pending more extensive review. In response to comments, EPA acknowledges that the RTC is in error in its statement that radon emissions from elemental phosphorus slag pose significant risks, as other EPA studies clearly show that the slag is not a significant source of radon emissions. However, the fact that radon gas emissions from elemental phosphorus slag are inconsequential does not eliminate concern about the potential for direct exposure to gamma radiation emitted from the slag.

Slag From Primary Zinc Processing. Regarding the questions raised in Step 1 of the Agency's decision making process, a careful review of the RTC information and public comments on zinc slag leads to the following three conclusions.

Based on available data, zinc slag frequently exhibits EP-toxicity, as 25 of 37 samples contained lead in concentrations that exceed the EP-toxicity regulatory level by a factor of between 5 and 13. Using the SPLP test, however, lead concentrations never exceeded the EP toxicity regulatory level, although the SPLP test has been shown on occasion to underestimate the amount of leachable lead in a sample.

At the same time, based on a review of existing waste management practices and predictive modeling results, EPA believes that zinc slag, as currently managed at the sole active facility in Monaca, PA, poses an overall low risk to human health and the environment. For example, the Agency predicts that metals leached from zinc slag at the Monaca facility would be largely bound to subsurface soil and would not reach the deep useable aquifer within 200 years. Even if a shallower aquifer exists at the site as the RTC and one commenter suggest, any shallow ground water that may become contaminated with slag leachate is likely to discharge, without being withdrawn for human use, into the adjacent Ohio River via the steep bluff adjoining the site. The Ohio River is very large at this point, and EPA modeling predicts that it can readily assimilate any chronic loading of contaminants that may occur, and any such release would be controlled through permitting under the Clean Water Act.

A portion of the zinc slag is also sold for use at off-site locations as road gravel or construction aggregate, and another portion is stockpiled until it can be sold for off-site use as a source of iron. Given the high concentrations of lead measured in EP leach tests of zinc slag, EPA recognizes that possible off-site use locations may be more conducive to releases and risks than the existing processing facility in Monaca, PA, although the Agency has no evidence that such risks are occurring or would occur. In fact, the Agency did not discover any damages attributable to such slags used off-site.

Third, EPA did not discover any damage cases attributed to zinc slag at the Monaca facility. Damage case studies at inactive sites did demonstrate the potential for surface water contamination via stormwater run-off from zinc slag piles, however. While these cases demonstrate the potential for problems if zinc slag is not properly controlled, they do not by themselves indicate that more stringent controls are needed for slag at the one active facility. In fact, the lack of documented damage associated with the active facility supports the conclusion that zinc slag as currently managed at that facility poses a low risk. One commenter argued that the lack of damage case data from the active facility may be a reflection of the inadequacy of the facility's environmental monitoring system, and not the absence of actual damage. However, the Agency believes that slag at the Monaca facility does not pose a threat, principally because the slag composition at the Monaca facility is not considered comparable to that of the inactive facilities, i.e., it arises from feedstocks having a different chemical composition. It should also be noted that with respect to the commenter's specific point, the facility has been in operation for over 50 years and there are no available monitoring data that show any

[6] To be regulated under subtitle C the waste would have to be listed as a hazardous waste because it does not exhibit any of the four characteristics that would otherwise classify it as a hazardous waste.

evidence of damages resulting from the management of zinc slag.

The Agency considered these findings, by themselves, to be insufficient to support a final regulatory determination. Although on-site risks and damages at the sole active facility are low, the elevated EP leachate concentrations (as well as difficulties in interpreting the low SPLP leachate concentrations) and the prospect of zinc slag being managed at off-site locations that may present a problem prompted the Agency to proceed to Step 2 of its decision making process to determine whether more stringent regulation is necessary and desirable. In answer to the questions addressed in Step 2, the Agency found that:

• The waste management practices and environmental conditions that currently limit the potential for significant threats to human health and the environment at the Monaca facility are expected to continue in the future in the absence of subtitle C regulation. Similarly, management practices at off-site locations would not be expected to change significantly. The characteristics of the slag are also unlikely to change in the future.

• EPA's recently promulgated stormwater regulations (55 FR 47990, November 16, 1990) under the Clean Water Act will minimize the potential for adverse impacts of stormwater run-off from zinc slag piles in the future.

• The only potential problem associated with these slags that EPA has identified is with their off-site use or disposal. However, the Agency has no evidence that such use or disposal is resulting in environmental damage. Control under subtitle C would impose significant and specific requirements (e.g., liners, closure and post-closure care) that are directed at controlling releases/risks that do not appear to exist or are otherwise controlled and, thus, are not appropriate given the special status of the waste.

Finally, the Agency notes that the State of Pennsylvania has proposed regulations that would impose more stringent environmental controls on the on-site management and off-site use of zinc slag, although the exact nature and extent of these controls cannot be predicted with certainty. The proposed rule would require generators to certify that they have attempted to reuse and/or recycle the slag before disposal and would require permits to contain provisions for liners, leachate collection systems, monitoring wells, and disposal of leachate.

Based on these combined findings from Steps 1 and 2, EPA concluded that regulation of zinc slag under subtitle C is inappropriate under the circumstances. (As a result, the Agency did not proceed to evaluate the questions addressed in Step 3 of its decision making process.)

Air Pollution Control (APC) Dust/Sludge From Iron Blast Furnaces. Addressing the questions in Step 1 of the decision making process, the information provided in the RTC and in public comments on the RTC leads to the following findings for this waste.

First, EPA found that lead concentrations measured in iron blast furnace APC dust/sludge leachate using the EP leach test only occasionally exceeded the EP-toxicity regulatory level (4 out of 70 samples from 3 out of 16 facilities with data). In addition, the waste is recycled (completely at one facility and partially at another) at two of the three facilities where the waste was found to be EP-toxic. Although lead concentrations determined by SPLP analyses never exceeded the EP toxicity regulatory level, the Agency has difficulty interpreting these measurements because the SPLP test has been shown on occasion to underestimate the amount of leachable lead in a sample.

At the same time, based on an examination of the site specific conditions at 15 of the 26 facilities that generate this waste, current management practices and environmental conditions are highly variable, with the potential for contaminant releases existing at some sites. For example, there is potential for ground-water contamination at five facilities that manage at least some of the dust/sludge in surface impoundments, although the low EP leachate concentrations at these facilities (none exceeded the EP-toxicity regulatory levels) would appear to suggest that any such contamination would not likely be significant. The dust/sludge also consists of small particles that are amenable to release and transport via stormwater and wind erosion when the waste is managed in exposed piles. Due to site-specific management practices and environmental conditions, there appears to be some potential for migration into surface water at four facilities and a potential for airborne releases and exposures at seven facilities.

One commenter argued that risks posed by this waste could be substantially higher than reported, because, as the commenter pointed out, the RTC did not consider the site-specific conditions at all active facilities, inactive facilities that could be reactivated in the future, and potential new facilities. While the commenter raises a good point, the Agency notes that the sample of facilities examined in the RTC represents more than half (15) of the 26 active facilities and seven of the ten states where active facilities are located. Furthermore, the conditions examined in the RTC represent a wide diversity of management practices and environmental conditions. Specifically, all known management practices for the dust/sludge were represented by the 15 sample facilities, including disposal methods (landfills and ponds) and temporary storage methods (storage pads and transfer areas), such as might be present at facilities that recycle the waste or send it off-site for disposal. Some of these units are equipped with engineered controls to prevent releases (e.g., liners and run-off controls), while others are not. In terms of environmental conditions, the facilities examined represent a variety of depths to ground water, net recharge rates, distances to surface water, and proximities to potential receptors. As a consequence, the Agency believes that the facilities examined reasonably represent the conditions that might exist at the other facilities. EPA thus believes that the hazards that were evaluated reflect the diversity and nature of hazards posed by iron blast furnace APC dust/sludge at the other facilities.

Finally, despite the Agency's theoretical conclusions about the potential for iron blast furnace APC dust/sludge to be released into the environment at some facilities, EPA did not find any damage cases attributable to this waste, which EPA believes to be significant when evaluating the actual hazards posed by special wastes. One commenter alleged that there are such documented damage cases, but that EPA did not discover them because it did not review files for inactive sites and other key information sources. However, as stated in the Agency's responses to comments on the RTC's analytical methodology (see appendix A of this preamble), the Agency maintains the view that its damage case investigation effort for these and other wastes was comprehensive and thorough. The Agency closely evaluated the specific information sources referenced by the commenter and, though the information clearly shows environmental problems at ferrous metal production facilities, EPA does not believe that the damages can be attributed to the special wastes studied in the Report to Congress. For example, surface water and ground-water impacts were found related to "slag landfills" at two facilities, but the landfills contained a number of co-disposed wastes, including sludges, fly

ash, waste acid, and coke plant tars, all of which may have contributed to the observed impacts.

In summary, this waste exhibits hazardous waste characteristics only rarely—only three facilities out of 16 with data generate dust/sludge that exhibits the toxicity characteristic, and even then the data suggest that the waste exhibits the characteristic only occasionally. Moreover, the waste is recycled (completely at one facility and partially at another) at two of the three facilities where it occasionally exhibits the toxicity characteristic. The Agency recognizes that existing waste characteristics, management practices, and environmental conditions could lead to releases at selected facilities. However, the low EP leachate concentrations at most facilities and the lack of documented cases of damage attributable to the dust/sludge indicate that the potential effects of such releases are not of sufficient magnitude to warrant removal of the special status of these wastes. In addition, EPA's recently promulgated stormwater regulations (55 FR 47990, November 16, 1990) under the Clean Water Act will minimize the potential for adverse impacts of stormwater runoff from the dust/sludge. Based on these findings, EPA concludes that regulation of this waste under subtitle C is inappropriate under the circumstances. (Accordingly, the Agency did not evaluate the questions addressed in Steps 2 and 3 of its decision making process.)

Basic Oxygen Furnace and Open Hearth Furnace Air Pollution Control (APC) Dust/Sludge From Carbon Steel Production. Based on a review of information in the RTC, supplemental analysis, and public comments on steel APC dust/sludge, EPA's responses to the questions in Step 1 of the decision making process are basically the same as those outlined above for iron blast furnace APC dust/sludge. Specifically:

• Steel APC dust/sludge appears to be EP-toxic only rarely. Of seven samples analyzed from five facilities, the concentration of selenium exceeded the EP-toxicity regulatory level in only one sample, and in this one case, only by a factor of 1.5. Selenium concentrations as determined by SPLP analyses did not exceed the EP-toxicity level.

• Based on an examination of the site-specific conditions at 11 facilities that generate the dust/sludge, current management practices and environmental conditions are highly variable, with the potential for contaminant releases existing at certain facilities. Like the iron blast furnace APC dust/sludge, however, there appears to be only a minor potential for ground-water contamination at a few facilities that manage the steel APC dust/sludge in impoundments. The steel APC dust/sludge consists of small particles that would be amenable to release and transport via stormwater and wind erosion if the waste is not properly controlled.

• EPA did not identify a single case of documented damage that can be attributed to steel APC dust/sludge.

Based on these findings, EPA concludes that subtitle C regulation for steel APC dust sludge is inappropriate under the circumstances that exist. (Therefore, the Agency did not employ Steps 2 and 3 of its decision making methodology.) The basic rationale for this conclusion is the same as that for iron blast furnace APC dust/sludge. That is, the dust/sludge rarely if ever exhibits a characteristic of hazardous waste. Although existing management practices and environmental conditions have the potential for environmental releases at certain facilities (although no evidence exists that such contamination has occurred or would occur), the waste's low contaminant concentrations and lack of damage cases indicate that the potential for adverse effects is not of sufficient magnitude to warrant removal of the special status of the waste. Thus, to the extent that additional controls may be justified, and state management controls are deemed to be inadequate, EPA may pursue appropriate controls for steel APC dust/sludge management under the Subtitle D program being developed for mineral extraction and beneficiation wastes.

Calcium Sulfate Wastewater Treatment Plant Sludge From Primary Copper Processing. In the Report to Congress, EPA tentatively recommended subtitle C regulation for this waste under Approach 1B. However, EPA received data in comments indicating that only one facility now generates and disposes of this sludge. In addition, as outlined in section II of this preamble, the Agency modified Step 2 of its decision making methodology in response to public comments to deemphasize consideration of potential threats that could exist at any new facilities that open in the future in favor of the other Step 2 factors, in light of the speculative nature of EPA's predictions regarding industry expansion. The possibility of expansion was an important factor contributing to the RTC's Subtitle C recommendation for this waste. EPA, therefore, has reconsidered the RTC tentative recommendation, focusing only on the remaining active generator (located in Garfield, UT).

Addressing the three questions considered in Step 1 of the decision making process:

• The sludge at the Garfield facility is EP-toxic for arsenic (7 out of 7 samples average 44 times the regulatory level), cadmium (6 of 7 samples average 3 times the regulatory level), and selenium (7 of 7 samples average 5 times the regulatory level). SPLP leach test concentrations, however, were below the subtitle C regulatory levels for all of the samples analyzed.

• One commenter argued that calcium sulfate sludge poses a large risk that should be controlled under subtitle C; however, based on a review of existing management practices and the arid setting of the Garfield facility, EPA believes that the hazards associated with calcium sulfate sludge at this site are low. Predictive modeling that accounts for the low net recharge and high evaporation rate, depth to ground water, and clayey subsurface at the site indicates that the potential for ground-water contamination is very low. Similarly, the potential for significant surface water contamination is negligible given the great distance of the sludge management units to the nearest surface water body (over 2 miles to the Great Salt Lake), and windblown dusting is significantly limited by the surface crust that forms on the dried sludge.

• No cases of documented damage caused by the sludge at the one active facility were discovered by EPA.

Even though the site-specific risk findings and lack of damage cases indicate that management of the sludge does not pose human health or environmental problems, the high intrinsic hazard of the sludge compelled EPA to consider additional factors before reaching a final regulatory determination. Therefore, EPA proceeded to Step 2 of its decision making process to examine whether more stringent regulation is necessary and desirable.

In Step 2, EPA found that current practices at the Garfield facility appear adequate to limit contaminant releases and associated risks in the future in the absence of subtitle C regulation. The sludge is well managed at present and the potential for releases appears to be precluded by the environmental conditions at this site. Specifically, potential releases to ground water are significantly limited by the site's very arid setting (liquids discharged to impoundments along with the sludge are expected to quickly evaporate and little precipitation and recharge is available to carry contaminants to the

subsurface), clayey subsurface, and depth to ground water (8 meters to the water table and 90 meters to the uppermost useable aquifer). Because the nearest surface water near the sludge units, the Great Salt Lake, is over two miles away, significant releases to surface water also should not be a problem. Finally, the potential for significant releases to air is limited because a surface crust forms on the dried sludge, largely preventing the wind from blowing dust into the air, and because the dried sludge is exposed to the wind only temporarily before it is stabilized and buried in an on-site landfill.

EPA also found in Step 2 that existing state regulatory programs provide only limited controls over the management of calcium sulfate sludge. Some commenters argued that the RTC's analysis of state regulations significantly understates the regulatory requirements applicable to copper processing wastes. However, upon further consideration of available information and communication with state officials, EPA concludes that the states have been regulating copper processing wastes, including calcium sulfate sludge, only to a limited extent. However, as discussed below, the Agency does not believe, based on available information, that this limited regulation has resulted in any environmental problems.

Finally, EPA also concluded in Step 2 that Subtitle C regulation of calcium sulfate wastewater treatment plant sludge would impose significant and specific requirements (e.g., liners, caps, ground-water monitoring) that are directed at controlling releases/risks that do not appear to exist or are otherwise controlled and, thus, are not appropriate given the special status of the waste.

Based on these combined findings from Steps 1 and 2, EPA concluded that existing sludge management practices at the one facility in question currently limit the potential for damages. Therefore, considering all of these findings together, EPA concludes that subtitle C regulation of calcium sulfate sludge is inappropriate given the existing circumstances. (Accordingly, EPA did not evaluate the questions addressed in Step 3 of its decision making methodology.) EPA may address the generation and management of this sludge under the subtitle D program under development for the mining industry.

This subtitle D determination differs from the RTC's tentative recommendation for two reasons. First, potential human health and environmental problems at one copper processing facility were dropped from consideration because public comments indicate that the facility no longer generates and disposes of calcium sulfate sludge. Second, the Agency agreed with commenters that concerns expressed in the RTC about potential problems at new facilities that may open in the future are somewhat speculative. Therefore, EPA did not place as much weight on these concerns in making the regulatory determination as it did in the RTC.

Chloride Process Waste Solids from Titanium Tetrachloride Production. In the RTC, EPA tentatively recommended subtitle C regulation for this waste under Approach 1B. However, additional data submitted in public comments and reanalysis of the RTC data indicate that the waste is not EP-toxic for lead as indicated in the RTC [6] and, therefore, is EP-toxic only for chromium. In addition, this waste would currently be exempt from subtitle C regulation by 40 CFR 261.4(b)(6), which exempts wastes that are hazardous only because they exhibit the EP toxicity characteristic for chromium, contain only trivalent chromium, and are managed in non-oxidizing environments. For these reasons, EPA decided to reevaluate the RTC's tentative conclusions.

Considering the three questions in Step 1 of the Agency's decision making process, the Agency has made the following findings. First, the waste is characteristically hazardous only as a result of its chromium content, which is currently exempted from regulation under subtitle C of RCRA by § 261.4(b)(6)(i)(A). In addition, chromium concentrations in the waste solids measured using the SPLP leach test are below the EP-toxicity regulatory levels, as indicated by further analysis of the RTC data and information submitted in comments.

Second, based on an examination of existing conditions at the nine active titanium tetrachloride facilities, EPA found that current management of the waste solids may allow contaminants to migrate in the environment at certain sites, but that the potential for this migration to cause significant impacts is low. For example, there appears to be a potential for leachate from this waste to reach ground-water at half of the sites, but predictive modeling at the "most sensitive" site indicates that contaminant concentrations at the property boundary would be below drinking water standards. Similarly, the Agency's modeling predicts that concentrations of contaminants in surface waters near the sites would be well below human health and environmental protection benchmarks, and that the risks associated with the inhalation of windblown dust from the waste solids piles would be negligible.

One commenter argued that the risks posed by this waste are sufficiently high to warrant regulation under subtitle C. In particular, the commenter argued that chemical concentrations (e.g., of chromium, lead, radium, and arsenic) in the waste solids could be much higher than the few samples examined in the RTC, that the wastes threaten fragile ecosystems near several of the facilities, and that drinking water threats could exist if private wells were installed closer to existing facilities. While EPA agrees there is always a possibility that the waste could contain higher chemical concentrations than those reported, the Agency used 17 samples from 7 facilities and believes the resulting characterization of the waste is adequate. The Agency also recognizes that several sites are located near "fragile" ecosystems: Six of the nine active facilities are located within 1,600 meters (1 mile) of a wetland, one is located within 2,600 meters of an endangered species habitat, and three are located within 1,600 meters of a National Park, Wildlife Refuge, or Recreation Area. However, the Agency's conservative modeling predicts that it is very unlikely that contaminants released from the waste solids management units could migrate to these areas in harmful concentrations. Finally, EPA's ground-water modeling for the "worst-case" facility predicts that contaminant concentrations at the property boundary are below health-based and ground-water protection criteria. Therefore, it does not appear that releases to ground water would pose a serious threat to the environments surrounding each plant.

Third, EPA found no documented cases of damage attributable to titanium tetrachloride waste solids. No evidence of damages was uncovered in the RTC's comprehensive review of all nine active and two inactive titanium facilities, and no new damage case information was submitted in public comments.

Based on these findings, EPA concludes that regulation of titanium tetrachloride waste solids under RCRA Subtitle C is inappropriate under the

[6] The sole sample found to contain lead above the EP-toxic level was determined to be for the waste acids and entrained solids discharged to an on-site impoundment, not the titanium waste solids (the special waste) that settle to the bottom of the impoundment. EPA has determined, therefore, that this sample is not appropriate for use in characterizing the waste solids.

circumstances. (Accordingly, the Agency did not evaluate Steps 2 and 3 of the decision making methodology.) Current on-site management practices do not appear to pose a significant risk. In addition, management practices are likely to be improving because the waste is currently comanaged with waste acids from titanium tetrachloride production, a waste that recently became subject to subtitle C controls. EPA plans to follow closely the changes in management practices that are expected to result from the change in regulatory status of the waste acids, changes that in some cases may result in management of the waste solids in units subject to subtitle C requirements. At those facilities where the waste is not managed in units regulated under subtitle C, EPA believes that releases that may occur can be adequately addressed under subtitle D given the special status of these wastes. In addition, in the final Toxicity Characteristic rulemaking, EPA indicated that it would re-evaluate the trivalent chromium exemption in § 261.4(b)(6) (55 FR 11812, March 29, 1990). If EPA finds that this exemption is not protective of human health and the environment and if an examination of titanium tetrachloride waste management shows any continuing or new problems, the Agency will reconsider this subtitle D determination for chloride process waste solids from titanium tetrachloride production.

Today's subtitle D determination is warranted and differs from the RTC's tentative recommendation primarily due to changes in the data base used to characterize the waste, such that the waste only exhibits the toxicity characteristic of hazardous waste for chromium and is exempt from subtitle C regulation. As discussed above, consideration of changes in management practices for waste solids that are expected as a result of the classification of waste acids from titanium tetrachloride production as a hazardous waste supports a subtitle D decision. In addition, if the decisionmaking process had been carried to Step 2, the fact that the Agency modified Step 2 of its decisionmaking methodology (in response to public comments) to deemphasize consideration of potential threats that could exist at any new facilities that open in the future, would also have contributed to the change from the subtitle C tentative recommendation in the RTC to today's subtitle D regulatory determination.

Slag from Primary Lead Processing. In the Report to Congress, EPA tentatively recommended subtitle C regulation for lead slag under decision making Approach 1B. Further Agency analyses in response to public comments, however, provided a clearer picture of the three damage cases presented in the Report and the risks associated with one facility's practice of shipping its slag off-site for disposal. EPA, therefore, reconsidered the RTC's tentative recommendation to account for this additional information.

Addressing Step 1 in the Agency's decision making process, which evaluates whether management of the waste poses human health or environmental problems, EPA made four basic findings. First, lead slag is EP-toxic using results of the EP leach test; EP-toxicity leach tests show that lead exceeded the regulatory level at all five active facilities in a total of 27 out of 101 samples; the maximum lead concentrations exceeded the regulatory level by a factor of 19. Cadmium concentrations exceeded the regulatory level at two facilities, by as much as a factor of seven. Arsenic, mercury, and selenium concentrations also exceeded the regulatory levels at the one facility that is only a refinery (the other facilities are either combined smelters and refineries or, in the case of one facility, only a smelter). No samples analyzed using the SPLP test contained contaminants in concentrations above the EP-toxicity regulatory levels; however, the SPLP test has been shown on occasion to underestimate the concentration of leachable lead in a sample.

Second, current practices for managing lead slag at the five active lead processing facilities appear to limit the potential for significant impacts caused by the slag. The potential for lead slag to cause significant surface water contamination at all but one facility is limited by the use of control systems that retain and treat stormwater run-off from slag piles prior to discharge, or by an expected small contaminant loading that is well within the assimilative capacity of nearby water bodies and is subject to control under the Clean Water Act. Risk modeling indicates that stormwater erosion of a lead slag pile at one facility could result in surface water contamination. However, due to releases to ground water from unlined wastewater ponds at this facility, the site is presently being cleaned up under the Superfund program, and any potential surface water impacts associated with erosion from the slag pile will be addressed as part of the site's overall Superfund response. EPA's recently promulgated stormwater regulations (55 FR 47990, November 16, 1990) under the Clean Water Act will also minimize the potential for adverse impacts of stormwater runoff from lead slag.

The Agency's modeling indicates that it is possible for some contaminants to leach from lead slag piles at two of the active facilities and migrate into underlying ground water. However, increased on-site concentrations of constituents in ground water are expected to be well within applicable drinking water standards. Air pathway modeling also indicates that it is very unlikely for lead slag piles to cause harmful concentrations of contaminants in the air at the nearest residences. One commenter contends that lead slag should be regulated under subtitle C because windblown dust from slag piles could pose a significant risk by resulting in an accumulation of contaminated dust in residential areas where people could be exposed directly. However, a Remedial Investigation/Feasibility Study at the facility in East Helena, MT has shown that slag management is a very minor contributor to windblown particulate matter and accumulated dust in the site environs.[7] As much as 95 percent of the lead particulate matter measured in air near the East Helena facility was found to come from ore processing areas and other sources, not the slag piles.

Third, there is a greater potential for human health and environmental risk at two off-site municipal landfills where lead slag from one facility is disposed, although the Agency has no evidence that such management does present a substantial hazard. Although the total quantity of slag that is shipped to these off-site landfills represents only 3 percent of the total quantity of slag that is generated, the slag that is shipped off-site is the highly concentrated refinery slag that is consistently EP-toxic for mercury, lead, cadmium, arsenic, and/or selenium.

Fourth, historical slag management practices have clearly caused ground-water contamination at one site, but steps have since been taken to help prevent this contamination from occurring in the future. The RTC reported damage cases at two other lead facilities, but close examination of the RTC data and information submitted in public comments has eliminated one of the damage cases and called the other one into question. Specifically, EPA's ongoing Superfund evaluation at the lead facility in East Helena, MT has

[7] Comprehensive Remedial Investigation/Feasibility Study—ASARCO Incorporated, East Helena, Montana, March 30, 1990.

demonstrated that ground-water contamination at that site has been caused by two on-site wastewater impoundments. Contribution to the problem from the lead slag pile is thought to be limited, though further study is planned. At the other site, located in Boss, MO, observed ground-water contamination is not clearly attributable to slag, as it too may have been caused by nearby wastewater impoundments. The Agency's risk modeling predicts that ground-water contamination from the slag pile at this site is unlikely.

Based on these findings, EPA concludes that the potential for lead slag to cause significant impacts is limited by the current management practices and conditions at the five active facilities, but there is some potential for adverse impacts that may be caused by the off-site disposal of relatively small quantities of lead slag from one facility. Therefore, EPA proceeded to Step 2 of its decision making process to evaluate whether more stringent regulation is necessary and desirable. In this step of the process, EPA found that:

• Current practices at the off-site landfills that are receiving lead slag for disposal may not be adequate to limit contaminant release and associated risk. As mentioned above, these are municipal landfills that may or may not be adequately equipped to contain contaminant migration from lead slag.

• In Nebraska, where all of the present off-site disposal of slag takes place, the slag could continue to be managed at off-site locations in the future with minimal state regulation. The other states where primary lead processing occurs have varying degrees of regulatory control. The State of Missouri, for example, where three facilities are located, has recently developed strengthened permitting, closure, maintenance, and financial assurance requirements for facilities that manage mineral processing wastes. In addition, stormwater run-off from lead slag piles into nearby surface waters is subject to control under the Clean Water Act in all three states where the slag is currently managed.

• Because subtitle C regulation would subject the slag to strict hazardous waste management standards, it would prevent the disposal of slag in municipal landfills. However, a subtitle C determination for this waste would also impose significant and specific requirements for on-site management (e.g., liners, closure and postclosure care, ground-water monitoring) that are directed at controlling releases/risks that do not appear to exist or are otherwise controlled at the five active lead processing facilities and, thus, are not appropriate given the special status of the waste. In particular, the Agency does not believe that it is appropriate to subject the entire industry to stringent subtitle C controls when any potential problems appear to be associated primarily with only 3 percent of the lead slag that is currently produced.

Based on the combined findings from Steps 1 and 2, EPA concludes that regulation of the waste under subtitle C is inappropriate under the circumstances. (Accordingly, EPA did not proceed to evaluate the questions addressed in Step 3 of its decision making process.) The Agency, therefore, will work to ensure that both on-site and off-site slag management practices are adequately protective under subtitle D and under the Clean Water Act. In particular, EPA will investigate further the offsite disposal practices used by the Omaha facility to determine the extent to which slag is currently co-disposed with municipal waste. If the management of this waste does prove to be problematic, EPA may, for example, classify co-disposal of the slag with municipal wastes as open dumping under RCRA section 4004. Open dumping is a prohibited practice under criteria promulgated under section 4004.

This determination differs from the RTC's tentative recommendation primarily because the Agency closely reexamined the three lead slag damage cases discussed in the Report to Congress in response to public comments. As outlined above, this examination determined that controls have already been established at one site to address the problem, that another case appears to be mainly if not entirely due to wastes other than lead slag, and that attribution of the third case to slag management practices is questionable. Therefore, an important factor in tentatively recommending Subtitle C regulation in the RTC has been removed.

Process Wastewater From the Production of Hydrofluoric Acid. EPA tentatively recommended subtitle C regulation for hydrofluoric (HF) acid process wastewater under Approach 1A and 1B in the Report to Congress. Additional data submitted in public comments and follow-up with the State of Louisiana, however, confirm that the documented damages cited in the Report are attributable to phosphoric acid wastewaters, and not HF process wastewater as reported in the RTC. EPA also found that two of the three active HF acid production facilities neutralize their wastewater. Accordingly, EPA has reconsidered the RTC's tentative recommendation.

Reconsidering the three questions addressed in Step 1 of the Agency's decision making process, the Agency reaches three basic findings. First, all nine samples of process wastewater analyzed (from two of three active facilities) exhibited the hazardous waste characteristic of corrosivity. However, no constituent concentrations exceeded EP-toxicity regulatory levels (all eight inorganic constituents with EP toxicity regulatory levels were measured in concentrations that were no more than 0.6 times the regulatory levels).

Second, as the RTC and one commenter who argued for subtitle C regulation pointed out, there is a relatively high potential for process wastewater to migrate into shallow ground water at the three active facilities. However, EPA does not believe that this migration will pose significant health risks, either because the shallow ground water is not likely to be used at close downgradient distances or because the waste management units are equipped with controls (e.g., a monitoring well network and slurry walls) to detect and help contain ground-water contamination.

One commenter identified a number of factors that would, according to the commenter, tend to make risks higher than presented in the RTC (e.g., the presence of shallow ground water, the current lack of liners beneath existing impoundments, the potential for changes in population and land use patterns leading to higher risks in the future, the wastewater's corrosivity, and the close proximity of each existing facility to wetlands). All of these factors were considered in the RTC and contribute to EPA's concern that shallow ground water near existing units may be affected. However, EPA does not agree that the RTC understates the potential impacts associated with this contamination, because the concentrations of contaminants in the wastewater are generally low. No constituents in the wastewater were measured in concentrations above the subtitle C regulatory levels, and few exceeded the highly conservative risk screening criteria used in the RTC by more than a factor of 10. Therefore, although the ground-water may become contaminated above levels of concern in the immediate vicinity of waste management units, contaminants are not expected to migrate downgradient to potential human or ecological exposure points.

Third, new data provided in comments appear to indicate that shallow ground water at one of the active facilities has been contaminated

with sulfate, total dissolved solids (TDS), and fluoride.[8] Concentrations of sulfate and TDS in a few wells surrounding wastewater management units exceed upgradient concentrations and secondary drinking water standards (designed to prevent an unpleasant taste). Fluoride concentrations in the ground water exceed background concentrations but do not exceed the health-based drinking water criterion. Contamination above the sulfate and TDS standards appears to have migrated at least 50 meters downgradient from the units. No significant effect on pH has been observed, however, even though the very low pH of the wastewater would appear to pose the greatest threat. In addition, no data are available on the concentrations of metals and other constituents with subtitle C regulatory levels, but any contamination by these constituents is expected to be minor because concentrations in the wastewater are low, as discussed above. No other cases of documented damage attributable to HF acid process wastewater are known to exist.

Based on these findings, EPA concluded that additional waste management controls for HF acid process wastewater might be appropriate, and proceeded to Step 2 of its decision making process. In this step of the process, the Agency found that:

• Current practices at two of the three active facilities are probably adequate to limit contaminant release and associated risk. One of the two manages the wastewater in a surface impoundment bounded by a slurry wall and conducts ground-water monitoring, while the other neutralizes the wastewater prior to using it for gypsum transport.

• It does not appear that existing state controls adequately address the management of this waste at all facilities. Of the three states where active facilities are located (LA, TX, and KY), Louisiana appears to be most comprehensive in its regulation of hydrofluoric acid process wastewater. The other two states impose less stringent requirements, though Kentucky recently proposed new solid waste regulations that may address process wastewater more directly.

• Though the corrosivity of the wastewater is a potential concern, it does not appear to pose a significant problem at the three active facilities based on available ground-water monitoring data. In addition, the concentrations of RCRA Appendix VIII constituents in the waste are low enough that they are not expected to result in exceedances of applicable standards in ground water. Regulation under subtitle C would also impose significant and specific requirements (e.g., liners, financial responsibility) that are not appropriate given the special status of the waste.

Based upon the combined findings of Steps 1 and 2, EPA concludes that regulation of process wastewater from hydrofluoric acid production under subtitle C is inappropriate. Although the waste exhibits the hazardous waste characteristic of corrosivity, the low pH of the wastewater does not appear to pose significant human health or environmental hazards at the three active facilities. Moreover, the only constituents which were found in the wastewater at significant levels (e.g., sulfates, fluoride) are not listed in appendix VIII of part 261. Thus, aside from corrosivity, subtitle C would not identify or list this waste as hazardous under subtitle C. Consequently, to the extent that state programs are determined to be inadequate, the Agency plans to pursue methods within the developing subtitle D mining wastes program to control risks posed by this waste. (Accordingly, EPA did not proceed to evaluate the questions addressed in Step 3 of its decision making process.)

This determination differs from the RTC's tentative recommendation primarily because the Agency closely reexamined the reported damage case in response to public comments. As outlined above, this examination demonstrated that the damages described in the RTC are actually attributable to a different waste, rather than to HF acid process wastewater. Therefore, the primary reason for tentatively recommending subtitle C regulation in the RTC has been removed.

Phosphogypsum and Process Wastewater from Phosphoric Acid Production. The Report to Congress considered two special wastes from phosphoric acid production: Phosphogypsum and process wastewater. EPA believes that it is appropriate to address these two wastes together in this regulatory determination. Although the wastes do not necessarily have to be co-managed, all of the active phosphoric acid facilities presently manage the gypsum and wastewater together in one system, consisting of a phosphogypsum stack and associated impoundments.[9] Therefore, it is not possible to make a determination for one waste without, in practice, affecting the status of the other waste at all of the operating facilities. In addition, though the two wastes have distinct physical and chemical properties, it is very difficult to attribute environmental problems in the vicinity of the waste management units to one waste or the other. Moreover, given the existing co-management of the wastes, it is also appropriate to evaluate the two wastes together from the standpoint of alternative management practices and cost/economic impacts.

In the Report to Congress, EPA tentatively recommended Subtitle D-Plus regulation for both phosphogypsum and process wastewater. Since publishing the RTC, EPA has conducted a supplemental analysis of management technologies and state regulations for the two wastes, and received and evaluated public comments on the RTC and supplemental analysis. In addition, in response to public comments, EPA has more closely evaluated existing ground-water monitoring data for the active phosphoric acid facilities and analyzed the potential costs associated with the corrective action provisions in RCRA sections 3004(u) and 3008(h). EPA therefore reconsidered the RTC's tentative recommendation to account for this additional information.

Addressing Step 1 in the Agency's decision making process, which evaluates whether management of the wastes poses human health or environmental problems, EPA made three findings.

First, both the gypsum and process wastewater exhibit a characteristic of hazardous waste, but the gypsum appears to do so only rarely. Out of 11 facilities with data on the composition of phosphogypsum, only the gypsum at the facility in Rock Springs, WY exhibits the characteristic of EP-toxicity. Two out of two samples of phosphogypsum from this facility contained concentrations of chromium that exceed the toxicity characteristic regulatory level, by a factor of six, on average. This appears to be a characteristic restricted to gypsum derived from the processing of certain phosphate rock mined in Utah and processed at the Rock Springs facility. Available data indicate that the concentrations of chromium and other EP constituents in gypsum at facilities in Louisiana and Florida, which process rock from Florida, and facilities in Idaho and North Carolina, which process locally derived rock, are usually one to

[8] This information does not constitute a documented damage case.

[9] The gypsum is slurried to the stack using process wastewater and large quantities of the wastewater are held in the interstitial pore spaces within a phosphogypsum stack.

two orders of magnitude below the regulatory levels.

In contrast, the process wastewater routinely exhibits the hazardous waste characteristic of corrosivity (i.e., it has a pH of less than 2). Out of 15 facilities with data, all process wastewater samples examined at six facilities had a pH less than 2 and most samples examined at six other facilities had a pH below 2. All of the pH values available for the other three plants with data are greater than or equal to 2. Process wastewater at three out of six facilities with data also exhibits the toxicity characteristic. A total of 19 of 19 wastewater samples from the three facilities contained cadmium concentrations that exceed the regulatory level (by a factor of four on average), and two out of two samples from one of the facilities also contained chromium concentrations that exceed the regulatory level (by a factor of two, on average).

Second, existing practices for managing phosphogypsum and process wastewater appear to pose substantial risks of environmental contamination and impacts through the ground-water and surface water pathways. Considering the hydraulic head created by gypsum stacks and process wastewater impoundments and the net recharge, depth to ground water, and subsurface permeability at the 20 active facilities, EPA believes that there is a moderate to high potential for ground-water contamination across the industry. This potential for ground-water contamination is limited significantly at the one Wyoming facility, which has equipped its waste management units with synthetic liners and a seepage collection ditch, but the units at most other facilities are either unlined or only lined with the clay and silt that naturally exist in the area. EPA's concern about potential ground-water contamination at the 11 facilities in Central Florida is compounded by the presence of underlying karst in the deep Floridan Aquifer; karst is prone to form caverns or solution cavities that can serve as contaminant migration pathways. Available data indicate that the background ground-water quality is suitable for drinking [10] and that there is either a private or public well, where potential human exposures could occur, within 1,600 meters (1 mile) downgradient of the waste management units at 14 of the 20 active facilities. In addition, 15 of the active facilities are located within 1,600 meters of a wetland and 16 facilities have waste management units within 500 meters (less than a third of a mile) of a surface water body where contamination could pose ecological threats. Phosphogypsum does not appear to pose a significant air pathway risk. Radon emissions to the air from gypsum stacks are controlled under the Clean Air Act at a level designed to ensure "acceptable" risk within an "ample margin of safety" (see 54 FR 51654, December 15, 1989). Windblown dust releases from gypsum stacks also appear to be effectively precluded by the crust that forms on the dried gypsum solids.

Third, a close examination of available monitoring data reveals that there are numerous cases of documented ground-water contamination across the industry. For example, out of 16 facilities with data, the phosphogypsum stacks and/or process wastewater ponds at 13 facilities appear to have caused groundwater contamination that exceeds background levels and primary (i.e., health-based) drinking water standards. Contamination by constituents with toxicity characteristic regulatory levels is seldom evident more than 500 meters from the waste management units, but other contaminants with health-based limits (gross alpha radiation, radium, and sodium) have migrated in potentially harmful concentrations over greater distances. Based on a review of the monitoring data and plant configurations, EPA believes that contamination above primary drinking water standards has migrated or is likely to migrate beyond the facility property boundary (unless corrective measures are implemented) at 12 of 15 facilities with data.

Based on these findings, EPA concluded that management of phosphogypsum and process wastewater poses potential health and environmental problems. Therefore, EPA proceeded to Step 2 of its decision making process to examine whether more stringent regulation is necessary or desirable. In this step, EPA found that:

• Current phosphogypsum and process wastewater management practices are often not adequate to limit contaminant release and associated risk. As discussed above, current management practices generally consist of disposal or storage in large unlined piles and ponds, typically in areas that are conducive to ground-water contamination.

• Current state and federal regulations generally do not appear adequate to control current and likely future ground-water contamination. Although Florida is in the process of developing strengthened regulations, the State presently permits the special waste units to contaminate ground water, usually as far as, but sometimes beyond, the facility property boundary. Given the intrinsic hazards of the wastes, the widespread potential for contaminant release and migration, and the potential for human and ecological exposures in the vicinity of active facilities, EPA believes a more stringent regulatory approach is needed.

• EPA believes that regulation under subtitle C would impose significant and specific requirements that are directed at controlling the types of releases/risks that have been documented for phosphoric acid production wastes across the industry.

Based on the combined findings from Steps 1 and 2, EPA concluded that existing management practices create the potential for environmental problems and that more stringent regulation is both necessary and desirable. EPA therefore seriously considered subtitle C regulation for the phosphoric acid wastes and proceeded to Step 3 of its decision-making process to evaluate the operational and economic consequences of a subtitle C determination.

In Step 3 of the decision-making process, EPA examined the costs and impacts of the three regulatory scenarios examined in the RTC and the Supplemental Analysis, and used the insights gained thereby in deciding whether the economic impacts of subtitle C (or C-Minus) regulation might cause extensive and significant economic dislocations within the phosphoric acid production industry. Cost impacts were reevaluated subsequent to release of the RTC and were based upon an integrated management strategy for controlling risks posed by the two special wastes in combination. This departure from the Agency's initial approach was required by new knowledge gained through additional plant visits and analysis; these findings are summarized in the Supplemental Analysis and discussed further in comment response documents.

Extensive comments received on the Supplemental Analysis have cast doubt upon the engineering feasibility of some of the waste management alternatives

[10] Background data for the surficial aquifers indicate that shallow ground water at the sites is generally drinkable, but low yields at the Florida sites limit uses primarily to irrigation and livestock watering. Lower aquifers, where present, are generally of equal or better quality, and appear to be either current or potential public drinking water supplies.

presented in that document. Consequently, the Agency has based its cost analysis in support of today's regulatory determination on the use of lined phosphogypsum stacks and cooling ponds (Engineering Alternative 3 in the Supplemental Analysis). The technology required to implement this alternative has been amply demonstrated (i.e., is feasible), though the costs involved are higher than those of some of the other alternatives evaluated in the Supplemental Analysis. Because EPA is not confident at present that full subtitle C compliance is technically feasible for existing phosphoric acid plants, principally because of the predicted operational effects of the large-scale lime neutralization required for compliance (the only Engineering Alternatives that would comply with promulgated Subtitle C Land Disposal Restrictions (LDRs) for corrosive wastes rely on lime treatment), the cost and impact analyses conducted for today's notice focus exclusively on the Subtitle C-Minus and D-Plus scenarios.

EPA has estimated that the total industry-wide cost of compliance with the Subtitle C-Minus scenario (assuming implementation of Engineering Alternative 3) would be approximately $465 million annually, with an additional $15 million to $60 million required annually for corrective action, depending upon the analytical assumptions employed. Estimated annualized compliance costs for the Subtitle D-Plus scenario are approximately one-third lower, at about $330 million for the industry in total; corrective action costs under this scenario could range from $13 million to $48 million annually. These costs represent from 10.0 to 21.6 percent of the value of shipments (VOS) under Subtitle C-Minus, and from 8.2 to 15.2 percent of the VOS under Subtitle D-Plus (excluding corrective action costs), depending upon the facility involved. Costs of this magnitude exceed typical operating margins in the affected industry, could not be passed through, and hence, could not be sustained over an extended period.

As required by Section 8002(p)(7), EPA has also conducted an analysis of the impacts associated with the costs of regulatory compliance. Based upon the results of this analysis, the Agency has concluded that the costs and impacts of regulatory compliance under the Subtitle C-Minus and D-Plus scenarios would be highly significant for most phosphoric acid facilities, with C-Minus costs being particularly difficult to withstand. These costs would create economic hardship for and threaten the continued economic viability of many of the facilities in the industry. Consequently, the Agency has decided that while the management of phosphoric acid production wastes requires additional controls, hazardous waste controls under RCRA are too inflexible and costly for the industry to implement and remain economically viable. Even a less rigorous approach under the auspices of RCRA Subtitle D could impose costs and impacts that the domestic industry would find difficult to withstand. Therefore, the Agency has serious reservations regarding the economic feasibility of a traditional waste management program designed within the contours of the RCRA statute.

Given these facts and the need for action to address the risks posed by phosphoric acid production processes and associated wastes, EPA believes that a different approach is required. The Agency has therefore developed a two-pronged approach to address these wastes. First, the Agency will rely upon existing authorities under RCRA Section 7003 and CERCLA Section 106 to respond effectively to emergency situations that arise. In addition, EPA will accelerate the collection of facility-specific information, consider the risks posed by these facilities, and take appropriate action to contain or stabilize wastes at facilities that present a risk to human health and the environment. In this manner, EPA believes that it can respond appropriately to any problems that arise while developing a program that is both adequately protective of human health and the environment and economically feasible and achievable for affected industry.

Second, EPA believes that a regulatory program specifically designed to address the complex issues associated with phosphoric acid industry special wastes can be developed under authorities afforded by the Toxic Substances Control Act (TSCA). Like RCRA, TSCA provides a mechanism to address threats posed to human health and the environment and, unlike RCRA Subtitle C, does not contain prescriptive requirements. TSCA provides the additional and significant advantage of being broader in scope, and explicitly allows EPA to address various parts of the production and waste generation process itself. Therefore, EPA plans to proceed with examination of this problem under TSCA to consider how to develop a program that will address phosphoric acid production practices and processes to reduce the risks posed by phosphogypsum and process wastewater.

The TSCA regulatory investigation already underway will focus on developing risk management strategies to reduce or eliminate risks posed by phosphoric acid production wastes. EPA is evaluating the chemicals and the processes involved in phosphoric acid production and the resulting wastes to determine how TSCA authorities can best be used to reduce the toxicity and/or volume of these wastes. The Agency will analyze the efficacy and feasibility of some of the alternatives to current practices that were described in the Supplemental Analysis, with an emphasis on developing sound methods (in both a technical and economic sense) of reducing the toxicity and/or the volume of the special wastes. EPA will assess pollution prevention opportunities based on a phosphoric acid life-cycle analysis, the Supplemental Analysis, and other information obtained during the TSCA investigation. The investigation will also address the risk reduction potential and associated costs for identified regulatory options, such as restrictions on manufacturing, processing, or disposal. Depending on the results of this assessment, site specific risk reduction strategies may be considered as most appropriate. As specific wastes or toxicity reduction techniques are identified, EPA will work with the industry to implement the most promising alternatives as quickly as possible. EPA believes that by developing a tailored program under TSCA, the Agency will be able to more fully explore, promote, and enforce several promising pollution prevention and/or source reduction ideas (e.g., more efficient raw product filtration, fluosilicic acid recovery) than would be possible under a RCRA program.

In addition, EPA plans to further explore and evaluate containment strategies of various kinds, so that whatever wastes are generated will not result in contaminant releases to the environment. If information obtained or findings developed during the TSCA investigation are such that RCRA could better handle this matter, the Agency will revisit today's regulatory determination, and determine whether subtitle C regulation of the phosphoric acid special wastes remains inappropriate.

IV. Decision To Postpone Consideration of a Possible Ban on Elemental Phosphorus Slag Utilization

In the RTC, EPA found that the radionuclide content and potential for

radiation risk is a concern for slag from elemental phosphorus production. The primary basis for this finding was EPA's Idaho Radionuclide Study,[11] which estimated that average life-time cancer risks range from $4x10^{-4}$ to $1x10^{-3}$ in Soda Springs and Pocatello, Idaho as a result of the use of elemental phosphorus slag in a wide range of off-site construction applications. Based on these findings, EPA stated in the RTC that it planned to use the authority of RCRA section 3001(b)(3)(B)(iii) to ban the use of the slag in construction and/or land reclamation when the Agency issued its regulatory determination for mineral processing wastes. EPA solicited comments on the appropriate regulatory language that should be used and how such a ban should be implemented.

In response, five commenters questioned the validity of the Idaho Radionuclide Study. The commenters argued that the study was not conducted according to required procedures, has not been sufficiently peer-reviewed, contradicts epidemiological studies that show that cancer risks in Idaho are low, and suffers from several technical flaws. For example, according to the commenters, the data collection methodology was inadequate to support valid risk estimation, the study relies on a zero threshold low-dose risk model that is not supported by experimental evidence, and the study relies on aerial radiation measurements that exaggerate actual radiation levels. The commenters argued, therefore, that the Idaho study cannot be used as a basis for a decision to ban off-site uses of the slag.

Since the release of the RTC, the Idaho Radionuclide Study and supporting data have been distributed for review by industry, EPA's Science Advisory Board (SAB), and the Agency for Toxic Substances and Disease Registry. A public hearing on the study was also held in Soda Springs, ID on August 21, 1990. Because of the concerns raised, EPA has postponed its final determination on the validity of the study's conclusions until the Agency decides how to incorporate SAB's findings and after the Agency's review of information provided at the public hearing is completed. In addition, the Agency is postponing its consideration of a possible ban on elemental phosphorus slag utilization until it completes its review of the technical basis for such an action. EPA will propose a supplemental notice at the appropriate time.

[11] EPA. 1990. Idaho Radionuclide Study. Office of Research and Development, Las Vegas Facility, Las Vegas, NV. EPA/520/6–90/008. April 1990.

V. Regulatory Flexibility Analysis

The Regulatory Flexibility Act (RFA) of 1980 (Pub. L. 96–354), which amends the Administrative Procedures Act, requires Federal regulatory agencies to consider "small entities" throughout the regulatory process. The RFA requires in section 603 an initial screening analysis to be performed to determine whether a substantial number of small entities will be significantly affected by a regulation. If so, regulatory alternatives that eliminate or mitigate the impacts must be considered.

EPA conducted a detailed analysis of the facilities and companies that generate the 20 special wastes from mineral processing during the preparation of the Report to Congress. The Agency established at that time that no companies that meet the definition of "small business" generate any of the special mineral processing wastes. Also, EPA has not received any information in public comment on the Report that would contradict this finding, and therefore concludes that today's action will not adversely affect small mineral processing companies. Consequently, an explicit Regulatory Flexibility Analysis is not required.

VI. Agency Initiatives

To follow up on the findings that have resulted in today's regulatory determination, EPA plans to continue several initiatives that directly relate to some of the mineral processing wastes addressed in this regulatory determination. These initiatives include the following four activities:

(1) Evaluation of the radiation exposures and risks associated with the off-site use of elemental phosphorus slag;

(2) Review of hazards posed by wastes containing diffuse naturally occurring radioactive material (NORM);

(3) development of a management program under RCRA Subtitle D for mineral extraction and beneficiation wastes; and

(4) Development of a program under TSCA addressing the phosphoric acid industry.

As discussed in section IV of this preamble, in April 1990, EPA released the Idaho Radionuclide Study, which provided an assessment of the direct radiation exposures and risks associated with the use of elemental phosphorus slag in construction in Soda Springs and Pocatello, Idaho. A public hearing on the study was held in Soda Springs, ID on August 21, 1990. EPA has also requested its Science Advisory Board (SAB) and other scientific organizations to review the study's underlying data, methodology, and conclusions. The SAB is scheduled to issue its findings this year. When available, EPA will review these findings together with other scientific and public inputs to define needs for further study. Final conclusions from this study will be used to help evaluate the need for any added controls on the off-site use of elemental phosphorus slag.

In a separate study, EPA is presently evaluating the characteristics, risks, and regulatory control options under TSCA for diffuse NORM wastes. The scope of this study is much broader than the Idaho Radionuclide Study, and includes phosphate and elemental phosphorus wastes, metal mining and mineral processing wastes (including wastes from bauxite and aluminum, copper, zinc, tin, titanium, and zirconium and hafnium processing), and a variety of other wastes (e.g., coal ash, oil and gas production scale, water treatment sludges, and certain consumer items). The purpose of the study is to determine whether the routine management of these wastes pose a sufficient radiological hazard to warrant additional regulatory controls. EPA plans to complete the study in the summer of 1991, at which time the Agency will begin to evaluate whether any added controls are necessary to limit the radiation hazards, what authorities exist for such controls, and what the form and substance of a NORM waste program might be. As appropriate, EPA will evaluate authorities and opportunities to address NORM wastes under RCRA, the Toxic Substances Control Act, and other programs.

EPA is in the process of developing a RCRA Subtitle D program for mineral extraction and beneficiation wastes. EPA plans to include those mineral processing wastes determined here to warrant regulation under subtitle D under the regulatory "umbrella" for extraction and beneficiation wastes, making it the extraction, beneficiation, and mineral processing wastes program. As the development of this program proceeds, the Agency may find it necessary to control certain mineral processing wastes, such as waste acids, that have little in common with the majority of extraction and beneficiation wastes under a separate regulatory program.

Finally, as discussed in the regulatory determination for the phosphoric acid wastes, EPA plans to proceed with an examination of phosphogypsum and process wastewater management under TSCA. EPA will consider how to

develop a program under TSCA, including pollution prevention opportunities, that will address phosphoric acid production practices and processes to reduce the risks posed by these two wastes.

VII. Regulatory Determination Docket

The EPA RCRA docket is located at: United States Environmental Protection Agency, EPA RCRA Docket, room M2427, 401 M Street, SW., Washington, DC 20460.

The Docket is open from 9 a.m. to 4 p.m., Monday through Friday except for Federal holidays. The public must make an appointment to review docket materials. Call the docket clerk at (202) 475–9327 for appointments.

Documents related to this regulatory determination are available for inspection at the docket.

List of Subjects in 40 CFR Part 261

Hazardous waste, Waste treatment and disposal, Recycling, Reporting and recordkeeping requirements, Manifests.

Dated: May 20, 1991.

William K. Reilly,

Administrator.

PART 261—IDENTIFICATION AND LISTING OF HAZARDOUS WASTES

1. The authority citation for part 261 continues to read as follows:

Authority: 42 U.S.C. 6905, 6912(a), 6921, 6922, and 6938.

2. Section 261.4 is amended by revising the last sentence of the introductory text of paragraph (b)(7) to read as follows:

§ 261.4 Exclusions.

(b) * * *

(7) * * * For the purpose of § 261.4(b)(7), solid waste from the processing of ores and minerals includes only the following wastes:

* * * * *

Note: The Following Appendices Will Not Appear in the Code of Federal Regulations.

Appendix A—Analysis of and Response to Public Comments on the Report to Congress

EPA received numerous public comments on the Report to Congress, including comments on the overall methodology used to evaluate the eight study factors and comments on the specific analysis and discussion of each of the 20 wastes. All of the comments are available for inspection in Docket No. F–90–RMPA–FFFFF. EPA has carefully considered each of these comments in developing this regulatory determination and includes in this appendix responses to certain major comments that have a particularly significant bearing on the Agency's final determination. All other comments and detailed responses are included in a supporting comment response background document, available for inspection in the RCRA docket.

I. Report to Congress Methodology

The Agency received a number of comments on the Report's scope (i.e., the particular wastes studied) as well as the approach that EPA used to evaluate five of the study factors: (1) Waste characteristics, generation, and current management practices; (2) potential danger to human health and the environment; (3) documented danger to human health and the environment; (4) compliance costs; and (5) economic impacts. Commenters did not raise significant methodological issues concerning the Agency's evaluation of Federal and State waste management controls or waste management alternatives and potential utilization.

A. Scope

Several commenters took exception to the Report's overall scope, with some stating that the scope was too narrow and some stating that the scope was too broad. The commenters that argued that the scope was too narrow said that EPA improperly narrowed the scope of the mining waste exclusion, leaving several mineral processing wastes potentially subject to subtitle C regulation when they should have been studied further in the Report to Congress. For example, one commenter said that certain wastes that exhibit a hazardous waste characteristic, such as coal tar wastes from historic town gas manufacturing, constituted exempt mineral processing wastes and should have been studied in the Report. The commenters that believed the scope was too broad said that EPA wrongly studied materials that are not solid wastes and thus not subject to RCRA regulation, such as some slags.

EPA believes the argument that the scope of the Report was too narrow is not an issue pertaining to the Report to Congress, but rather pertains to the scope of the Agency's final rulemakings interpreting the scope of the exclusion for mineral processing wastes. As EPA explained in the preambles to the rules as well as the Report to Congress, two final rules established the scope of the exemption for mineral processing, and EPA did not solicit further comment on this issue in the RTC. EPA also notes that the coal tar wastes mentioned in the comment are no longer generated (the last plant that manufactured gas for municipal use using coal closed in the 1970's) in high volumes (if they ever were), and the Bevill Amendment applies only to currently generated waste and historical stockpiles of currently generated waste. Moreover, the coal tar wastes remaining from historic town gas manufacturing are substantially different from the coal gas wastes studied in the Report to Congress, as the coal tar wastes have a different chemical makeup and were generated by different processes.

With respect to the argument that the scope of the Report is too broad, EPA acknowledges that some of the materials examined in the Report are not always solid wastes, depending on how they are managed in particular instances. In fact, if they are not defined as solid wastes under EPA's regulations, the Agency agrees that regulation under RCRA is not appropriate. However, the Agency believes that all of the materials examined are managed as a solid waste, as defined by RCRA regulations, at least part of the time at some facilities. Therefore, all of these wastes were appropriate for study in the mineral processing report.

B. Waste Characteristics, Generation, and Current Management Practices

One commenter argued that EPA's consideration of waste characteristics in the RTC did not recognize the variability in composition of a given waste from one facility to the next. According to the commenter, this variability provides support for a determination that subtitle C regulation is unwarranted because regulation under other state and federal authorities provides the flexibility necessary to address the geographic variability in waste characteristics (which subtitle C does not). For example, data for phosphogypsum and process wastewater from phosphate rock processing clearly demonstrate, according to the commenter, the variability of characteristics of these wastes and the relationship between that variability and the geographic origin of the phosphate rock being processed. The commenter went on to contend that the RTC used waste characterization data only to determine whether a waste contains constituents at concentrations of potential concern, ignoring the critical aspect of geographic variability.

EPA disagrees with this comment. Waste characteristics and the variability in chemical concentrations from one facility to the next were critical elements in the risk and cost analyses, as well as in the Agency's final decision making. Specifically, the variability in waste composition was

explicitly highlighted in the analysis of each waste's intrinsic hazard, and the facilities that were examined in the cost and economic impact portions of the analysis were selected as a function of whether their wastes exhibit a hazardous waste characteristic. If subtitle C regulation for a given waste warranted serious consideration based on an analysis of the study factors, EPA closely examined on a facility-by-facility basis the frequency and magnitude with which the waste exhibits a hazardous waste characteristic in order to reach a final regulatory determination.

C. Potential Danger to Human Health and the Environment

1. *Leaching Procedures.* Four commenters addressed the appropriateness of different laboratory leach tests used to measure contaminant concentrations in leachate from mineral processing waste samples. Three of the commenters objected to the RTC's use of data generated from the Extraction Procedure (EP) leach test. These commenters stated that EP leachate concentrations overestimate actual leachate concentrations because the EP test mimics an implausible mismanagement scenario in which mineral processing wastes are co-disposed with municipal solid waste in a municipal landfill and exposed to an organic leaching medium. In general, these commenters believed that analytical results from a distilled water leaching procedure or the Synthetic Precipitation Leaching Procedure (SPLP) would provide a more realistic assessment of the leachability of metals from mineral processing wastes under actual field conditions. In contrast, another commenter suggested that use of the EP leach test data is reasonable because, among other reasons, co-disposal with municipal wastes cannot be ruled out for some mineral processing wastes that are disposed off-site, and because at the time the RTC was being prepared, the EP leach test was the required procedure for determining whether a mineral processing waste would be regulated as EP toxic if the Bevill exemption was removed.

The Agency believes that the RTC's use of EP leach test data for mineral processing waste characterization and risk assessment is reasonable for three main reasons. First, use of the EP leachate data is a reasonably conservative approach. While several constituents were found to be present in higher concentrations in EP leachate than SPLP leachate for some samples that were tested using both procedures, results for the two tests are often similar (and for liquid wastes, they are identical since liquids are not leached, but simply compared directly to the appropriate regulatory concentration levels). There are also cases where EP leachate concentrations were found to be less than SPLP leachate concentrations. For example, the results of an EPA study [1] analyzing the validity of the SPLP test showed that the SPLP test has been shown on occasion to underestimate the amount of leachable lead in a sample.[2] Other constituents that are commonly present in higher concentrations in EP leachate than SPLP leachate include iron, zinc, aluminum, cadmium, copper, and nickel. In contrast, arsenic, vanadium, molybdenum, and barium are commonly found in higher concentrations in SPLP leachate than EP leachate. In addition to the fact that EP leachate concentrations appear reasonably conservative relative to the SPLP concentrations, the Agency believes use of the EP leachate data is reasonable because mineral processing wastes may be plausibly mismanaged in a municipal landfill in certain cases. For example, lead slag from one of the primary lead processing plants, and steel (basic oxygen furnace and open hearth furnace) air pollution control dust/sludge from one plant are presently shipped off-site for disposal in a municipal landfill. Given the existing regulatory regime, it is not inconceivable that other mineral processing wastes from other facilities could be disposed in a similar manner in the future.

Second, as noted by one of the commenters, the EP leach test at the time the RTC was being prepared was the legally required procedure for determining whether the mineral processing wastes under study exhibit the hazardous waste characteristic of EP toxicity. The test that has replaced the EP test, the Toxicity Characteristic Leaching Procedure, assumes the same mismanagement scenario and will also be used to determine the toxicity of wastes for regulatory purposes.

Third, the vast majority of available leachate data for mineral processing wastes are from EP leach tests. The amount of data from other laboratory leach tests or from samples of actual leachate collected in the field is insufficient to support a comprehensive evaluation.

The Agency recognizes that there are some uncertainties associated with using EP leachate data to estimate the concentrations of metals in leachate generated from the mineral processing wastes as they are currently managed. As a result, the differences between measured EP and SPLP leachate concentrations were factored into the Agency's decision making for this regulatory determination. Also, EPA acknowledges that the RTC's use of EP leachate data differs from the approach used in the Agency's previous rulemakings on mineral processing wastes (reinterpreting the scope of the Mining Waste Exclusion), but believes the reasons outlined above provide a sound basis for using the EP data in the analysis leading to the regulatory determination. In the previous rulemakings, the Agency used limited SPLP data in order to establish which wastes qualified as "low hazard" and thus were eligible for detailed study in the RTC (i.e., use of the SPLP data was a reasonable approach for selecting the wastes to be studies, because wastes that exhibit hazardous characteristics under the SPLP test are clearly not low hazard). For purposes of actually conducting a risk assessment, however, relying primarily on the EP leachate data is a reasonable, though more conservative approach. The overall conservativeness of EPA's risk assessment is discussed further below.

2. *Overall Conservativeness.* Five commenters stated that the risk assessment methodology in general relies on overly conservative assumptions that grossly overestimate risk and ignore contradictory real-life information. The commenters said the risk screening criteria used to evaluate the intrinsic hazard of each waste stream's composition are ultra-conservative, as they are based on worst-case assumptions regarding an unbroken chain of events that allow contaminant release, migration through the environment, and exposure to receptors.

While the Agency agrees that there are elements of the risk assessment methodology that tend to overestimate actual risks, these overestimates are offset somewhat by other elements of the methodology that tend to underestimate actual risks. The Agency acknowledges that most of the risk screening criteria are conservative, as stated throughout the RTC. However, the Agency used these criteria only for the purpose of analyzing the intrinsic

[1] Performance Testing of Method 1312—QA Support for RCRA Testing, U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Las Vegas, NV, March 1989. Docket No. F-89-MWRP-F0002.

[2] Given recent data that indicate that lead is a health hazard at significantly lower levels than previously believed (U.S. Department of Health and Human Services, Toxicological Profile for Lead, Agency for Toxic Substances and Disease Registry, June 1990), EPA believes it is especially important that it not rely solely on a procedure that may underestimate lead leachability.

hazard of each waste stream. EPA interpreted an exceedance of the criteria only as an indication that the risks of a given waste should be evaluated in more detail, not by itself as proof that the waste poses a significant risk. If a waste contained constituents in concentrations above the screening criteria, the analysis was supplemented with additional evaluation of conditions at actual facilities, and then further, if this evaluation indicated that there were potential problems, the Agency conducted risk modeling in order to develop final risk conclusions. The RTC then proceeded to evaluate the risk conclusions together with the damage case conclusions before reaching an overall finding on the hazards associated with each waste.

Overall, EPA believes that the risk assessment, while conservative, was reasonable in that EPA factored the uncertainties created by key assumptions in the risk assessment methodology into the regulatory decision making process for each waste stream. The approach that EPA used to evaluate potential human health and environmental problems is outlined in section II of this preamble and applied in section III, which presents the rationale for the final regulatory determination for specific wastes.

3. *Modeling Inadequacies.* One commenter argued that the Agency's risk modeling was inadequate and significantly underestimated risks because it did not adequately consider a number of specific factors. Important factors that the commenter alleged were left out or considered incorrectly include site-specific soil-water distribution coefficients (Kd's), the transport of metals in ground water by colloids, metal-organic complexing during ground-water transport, ground-water flow through karst terrains, storm events, evaporation and subsequent concentration of metals in small surface water bodies, and the transport of contaminated storm-water run-off to surface water bodies.

In general, EPA acknowledges these modeling limitations but believes most of them were unavoidable, forced in part by necessary limitations in the scope/complexity of the risk assessment, as well as by limitations in the state of ground-water modeling as a science. For example, the Agency agrees that Kd values are highly site-specific, but believes that modeling each site using actual Kd's would have required prohibitively extensive field measurements and verification. As a result, the Agency used the next best approach—EPA used its best professional judgment to select representative Kd values for each site and each contaminant, based on a review of data in the literature and an examination of available data on the soil composition at each site. In addition, with the possible exception of a few experimental models, the Agency is unaware of any reliable techniques for modeling the migration of colloids or the flow of ground water through karst. Overall, the Agency believes that its risk modeling approach accounts for the factors noted by the commenter in the best way possible, considering the study's time limitations. When significant factors could not be considered in the quantitative modeling exercise, they were considered in a qualitative manner so as to not compromise the overall completeness of the risk analysis.

4. *Lack of Consideration of Off-Site Use/Disposal and Future Changes.* One commenter argued that the risk assessment was deficient because it did not consider the risks associated with off-site use or disposal of the mineral processing wastes. This same commenter said the risk assessment is also fundamentally flawed because it analyzes risks only in terms of existing conditions at each facility that generates the mineral processing wastes, not accounting for possible future changes in water use patterns or population distributions.

While the Agency acknowledges that it did not rigorously model the risks associated with off-site use/disposal or possible future locations of new facilities, it disagrees that the RTC did not consider these factors.[3] Based on a review of the past disposal practices and potential utilization of each waste, only about half of the mineral processing wastes are candidates for off-site use or disposal, including copper slag, elemental phosphorus slag, all four of the ferrous metal production wastes, fluorogypsum, lead slag, phosphogypsum, and zinc slag. In the case of elemental phosphorus slag, the RTC relied on monitoring and risk modeling conducted by EPA's Office of Radiation Programs to evaluate the potential radiation hazards associated with off-site uses; as discussed in section VI of this preamble, EPA is in the process of re-examining the validity of this off-site modeling for elemental phosphorus slag. For the other wastes, EPA evaluated the observed and potential hazards associated with off-site use or disposal in the context of the wastes' damage case record and intrinsic hazard analysis, and factored the results of this evaluation into the overall hazard findings in each waste-specific chapter of the RTC. For example, before reaching conclusions about the hazards posed by iron blast furnace slag, a waste that has been shipped off-site for disposal and a variety of uses for decades, EPA searched for and evaluated any evidence of environmental damage caused by the off-site management practices. The conservative risk screening criteria used to evaluate each waste's intrinsic toxicity also were developed using hypothetical scenarios that might occur if the wastes were mismanaged (e.g., scenarios in which an inactive waste pile is not closed or maintained and people are allowed to come into direct contact with the waste). Therefore, the Agency believes that both off-site activities and possible future changes have been accounted for in the overall hazard conclusion for each waste stream. EPA also notes, however, that, as a general matter, the use of site-specific risk modeling and evaluation is appropriate for high-volume special wastes which are typically managed on-site.

5. *Treatment of Radionuclides in the Report to Congress.* One commenter claimed that EPA's treatment of radionuclides is different with respect to the four wastes tentatively proposed for removal from the Mining Waste Exclusion and the sixteen other wastes. The commenter argued that EPA has determined that some radionuclide risk exists for some of the sixteen wastes but instead of recommending subtitle C regulation, EPA merely expressed that it plans to further investigate the potential for exposure and associated radiation risk. This commenter added that if further investigation is warranted before regulatory action is taken on some wastes, the same principle should apply to all the wastes.

EPA could not evaluate the risks associated with radioactive constituents for all of the wastes studied in the RTC because the necessary data were not available. In addition, there presently are no controls for risks from radioactive materials under RCRA subtitle C, as there is not a hazardous waste characteristic test for radioactivity and no radionuclides or radioactivity levels are listed in appendix VIII to 40 CFR part 261 (Hazardous Constituents). As a result, concerns about residual radioactivity

[3] As discussed elsewhere, EPA did examine potential changes in exposure scenarios at existing facilities. For example, the Agency's risk modeling examined potential groundwater exposure points at locations closer to the facility than known current well locations (e.g., at the facility boundary).

would not be resolved by removal of the Mining Waste Exclusion, because such an action would not result in subtitle C regulation unless the waste exhibits a RCRA hazardous characteristic.

To the extent that data were available on the radionuclide concentration in various wastes, EPA believes that it evaluated the data and made final regulatory determinations for the wastes in a consistent manner. That is, EPA uniformly compared available radionuclide concentration data for the wastes to risk screening criteria and developed conclusions on the intrinsic hazard of the wastes accordingly. The Agency then evaluated potential radiation risk as an element in the overall risk assessment for each waste, and combined the risk assessment conclusions with the other RCRA section 8002(p) study factors in accordance with the decision making methodology outlined in section II of this preamble in order to reach a final regulatory determination. Therefore, radiation risk was but one element in an overall evaluation process, and EPA consistently followed that process to reach appropriate determinations for each waste. To the extent that radioactivity appears to be a concern for a given waste, EPA believes that potential radiation risks should be addressed along with the waste's other potential threats within the regulatory framework determined to be appropriate (subtitle D in all cases). In addition, EPA is examining potential radiation risks associated with these and other materials in studies currently underway.

D. Documented Danger to Human Health and the Environment

One commenter contends that many of the damage cases cited in the RTC are not attributable to Bevill processing wastes. The commenter also stated that other damage cases cited by EPA resulted from historical management practices that have long since been discontinued by the mineral processing industry. A number of commenters made this assertion regarding specific mineral commodity sectors and wastes as well.

The Agency reexamined the RTC data and evaluated the information submitted in comments and eliminated some of the damage cases covered in the RTC for the purpose of this regulatory determination (see the comment-response background document in the docket for details). For example, EPA has eliminated the damage cases for lead slag at the ASARCO facility in East Helena, MT and for hydrofluoric acid process wastewater at the Allied facility in Geismar, LA because available information indicates that the contamination documented in the RTC is attributable to other wastes.

Furthermore, as discussed in the RTC, inclusion in the RTC of documented contaminant releases to the environment due to discontinued waste management practices does not necessarily demonstrate that releases from current management practices will occur. The Agency believes, however, that damage case information on past waste management practices is useful in demonstrating the potential for environmental and human health impacts, for two primary reasons. First, these damage cases provide information on combinations of management practices and site conditions that have resulted in environmental problems, which is useful for anticipating and avoiding future problems. Second, damage cases associated with past practices, like those associated with ongoing practices, are useful in demonstrating the kinds of impacts that can result when hazardous constituents are released from the wastes. If damage case information on past waste management practices was available, EPA evaluated the particular circumstances involved to determine if the case represents conditions that are likely to exist today. If, in EPA's judgment, a historical damage case did not apply to current management practices, it was used to supplement the risk conclusions in the sense that it could demonstrate how problems can occur in mismanagement scenarios, but it was not given the full status of a damage case in making the regulatory determination. However, if a historical damage case was found to represent today's management practices, it was considered equally with any damage cases for current management practices in developing the regulatory determination.

One commenter claimed that the Agency did not meet the standard set by Congress that damage cases should relate to the individual waste stream being studied. The commenter added that although relating damage to a specific stream may be difficult, it is essential if an analysis is to be meaningful.

EPA disagrees with this comment. As mentioned previously, the Agency reexamined the RTC data and evaluated the information submitted in comments and eliminated some of the damage cases covered in the RTC because the damages could not be attributed to a given waste stream being studied. In some of the cases that were retained for the purpose of this regulatory determination attribution to a sole waste stream was not possible, because wastes were co-managed, for example. However, the Agency believes that at least one of the special wastes being studied was contributing to the damages described in cases used for the regulatory determination. This view is based on EPA's review of available data on waste management practices and site conditions as reflected in state or EPA regional regulatory files.

One commenter argued that contrary to the Agency's position, the absence of damage cases is not a reliable indicator of the absence of potential hazard from the wastes studied in the Report. The commenter stated that the lack of damage cases can be attributed to two factors: Deficiencies and flaws in EPA's methodology for identifying damage cases, and inadequacies within state programs for identifying damage cases.

The Agency has reviewed these comments and maintains the view that its damage case investigation effort was comprehensive and thorough. Many sources were utilized to obtain information on facilities, including the National Priorities List (NPL) and other lists; federal, state, and local regulatory agencies; public interest or citizen's groups; and professional and trade associations. In addition, EPA followed up on general and specific examples cited in comments and has not found any additional damage cases. For example, EPA has reviewed the evidence suggested by one commenter linking observed damages to ferrous metal production wastes, and concludes that any such damages are not attributable to any of the four ferrous metal production wastes studied in the Report. The Agency acknowledges that although damages may have occurred at some facilities not identified in the Report, documentation of these damages was not available or non-existent. This is precisely why the RTC's findings about the hazards of each waste stream are based on both an analysis of damage cases and risks in the absence of any known damages. Moreover, EPA believes that the lack of documented damages for a given waste stream does not necessarily signify a lack of hazard from that waste stream, but believes that the attribution of damage cases to a waste stream is the most concrete evidence of such a hazard.

E. Estimation of Compliance Costs

1. *Incorrect Cost Estimates.* Several commenters claimed that EPA had seriously underestimated the total compliance costs associated with subtitle C regulations by failing to consider several pertinent elements,

including: The cumulative financial impact of federal and state regulations (including the recent Bevill rulemakings); hydrogeological investigations that may include the construction of systems of ground-water monitoring wells; location requirements at facilities within a 100-year flood plain; land disposal restriction requirements; neutralization; recycling; remedial work to control releases; and closure activities. One commenter, on the other hand, asserted that EPA overstated the cost associated with compliance by assuming that more facilities exhibit hazardous waste characteristics than are indicated by available data. For example, the commenter stated that the Agency incorrectly assumed that wastewater at every facility would be regulated as hazardous, even though the wastewater may not actually exhibit hazardous waste characteristics at each operating plant.

The Agency generally disagrees with those commenters who argued that EPA underestimated compliance costs associated with subtitle C regulation. As part of its analysis, EPA did, in fact, address many of the cited compliance cost elements. In the Report to Congress, EPA accounted for ground-water monitoring systems, neutralization of wastes, location standards, land disposal restrictions (in some cases), and closure requirements. The cumulative impact of previous rulemakings is not relevant to the issue of whether the special mineral processing wastes studied in the Report to Congress can be managed under RCRA subtitle C without excessive additional costs being incurred by the regulated community. That is, the costs and impacts of regulating non-special mineral processing wastes under subtitle C have no relevance to today's regulatory determination. EPA acknowledges that, at certain facilities, corrective action requirements could result in potentially significant costs for some wastes and, thus, has given further consideration to the associated costs (further discussion of this issue is presented below).

On the other hand, EPA acknowledges that compliance costs may be overstated in certain instances in which wastes were assumed to exhibit a hazardous characteristic when in fact they may not. The Agency used this conservative assumption to overcome data limitations (i.e., a lack of EP-toxicity test data for some facilities) and to demonstrate the estimated magnitude of compliance costs at potentially affected facilities. While actual impacts may be less widely distributed, EPA believes that the approach employed was a reasonable way of demonstrating potential impacts to industry under subtitle C, as contemplated by the Bevill Amendment. In addition, the assumption of hazardousness at all facilities and the associated cost estimates did not affect the regulatory determination in a meaningful way (as discussed further below).

2. *Corrective Action Costs.* Several commenters complained that EPA failed to consider the appropriate costs associated with corrective action. Many of these commenters stated that by ignoring corrective action requirements under RCRA sections 3004(u) and 3008(h), EPA was failing to fulfill its statutory obligation under the Bevill Amendment, which requires EPA to study the costs of regulating Bevill wastes under subtitle C. A few of these commenters recommended that EPA revise its cost estimates to reflect necessary corrective action. One of these commenters also indicated that EPA has the information required to determine at least the range of likely corrective action costs.

In response to these comments, EPA has analyzed corrective action issues in further detail and estimated corrective action costs at certain facilities. EPA focused this analysis on only those wastes for which corrective action costs might influence the final regulatory determination: Phosphogypsum and process wastewater from phosphoric acid production. These are the only wastes for which application of EPA's decision making methodology required EPA to consider potential regulatory compliance costs. If cost had been a factor in the decision for the other 18 wastes, inclusion of corrective action costs would only have added support to the Agency's determination not to regulate these 18 wastes under subtitle C.

EPA's corrective action analysis reflects the probable response to the predominant source and type of contamination that has been observed at phosphoric acid facilities, namely contamination of underlying ground-water aquifers by the routine operation of gypsum stack-cooling pond complexes. The response strategy examined by EPA involves the installation of a ground-water containment system consisting of extraction wells (in some cases supplemented by a slurry wall) around the entire stack-pond complex. In this manner, contaminants entering the subsurface would be removed, thereby preventing them from further contaminating the affected aquifer(s). This strategy assumes that over time, existing contaminants present in the ground-water system would be diluted and/or attenuated to below MCLs (due in part to the gradual rise in ground-water pH caused by eliminating the continuous introduction of acidic process wastewater to an unlined stack/pond system), thereby obviating the need for active aquifer remediation activities over the entire contaminated area. The Agency has identified the facilities that would likely experience corrective action (under either a modified subtitle C or D situation), and has estimated the costs of implementing the response strategy described here. Details regarding EPA's methodology and the results of the analysis are provided in a Technical Background Document that they may be found in the supporting docket for today's notice. In general, corrective action costs are relatively modest [4], contrary to the unsupported statements of many commenters, and comprise approximately ten percent of total annualized compliance costs at the individual facility level.

3. *Land Disposal Restrictions Costs.* EPA received several comments stating that the Agency did not include specific estimates of costs associated with land disposal restrictions as they would apply to mineral processing waste types and sectors. One of these commenters argued that in the "third third" rule, EPA designates stabilization as BDAT for treating metal-bearing wastes, yet the Agency does not include stabilization costs in its RTC cost estimates. This commenter further argued that EPA should have considered the additional on- and off-site disposal costs associated with acquiring additional land for disposal on-site and transportation costs to a remote location.

Contrary to these assertions, EPA did evaluate land disposal restrictions costs for some of the wastes addressed in the Report to Congress, including sludges. These materials were assumed to be cement stabilized prior to disposal in subtitle C landfills. Moreover, the resulting increase in the volume of the wastes in question was explicitly factored into EPA's analysis, by calculating the incremental landfill volume required, adjusting the landfill

[4] The annualized compliance costs (ACC) of EPA's corrective action strategy for the twelve potentially affected facilities range from approximately $2.0 million to $6.9 million under the Subtitle C-Minus scenario, and from about $1.6 million to $5.7 million under the Subtitle D-Plus scenario.

design accordingly, and calculating the total cost of the necessary land disposal unit(s) for the wastes in question. In conducting the supplementary analysis of the phosphoric acid sector, the Agency also factored land disposal restriction costs (lime treatment) into the total costs for phosphogypsum disposal.

BDATs were not applied, and costs, therefore, were not calculated, for copper, lead, and zinc slags because of an assumption that slags, when generated, are similar to wastes that have been treated by vitrification (a BDAT). For this reason, stabilization was presumed to be an unnecessary management method for these wastes. (If stabilization is required, costs would increase, but this would not have affected the Agency's regulatory determination.) Transportation costs were not factored in for on-site management because data in EPA's possession and personal observations made during site visits to a substantial number of the facilities considered in the Report demonstrate that many, if not most, potentially affected facilities own land of adequate size contiguous with or close to their existing waste management units to construct new units of sufficient capacity.

4. *Costs Associated With Replacing Waste Management Units.* Some commenters argued that EPA failed to consider the costs associated with replacing subtitle C hazardous waste disposal facilities in the future (i.e., after the first operation is closed in year 15). These commenters suggested that such costs, when discounted to the present, are significant (i.e., on the order of 25 percent of the total compliance costs).

EPA acknowledges this comment to be true. A 15-year life without replacement of equipment or facilities was assumed for simplicity during the analysis. Data provided by facility operators in response to the 1989 SWMPF Survey and the Agency's understanding of relevant mineral commodity markets suggest that an assumed 15-year operating life is not unreasonable for some facilities. In other cases, however, it is unclear whether this is or is not a valid assumption. In those cases, the remaining life of the facilities cannot be predicted with accuracy. EPA acknowledges that in situations in which the facilities would continue to operate and would require new waste management units periodically, annualized compliance costs would increase over those reported in the RTC, even by 25 percent or more. In any event, such an increase does not effect today's regulatory determination.

5. *Accuracy of Cost Estimates.* EPA received several comments regarding the accuracy of its cost estimates. While many commenters argued that EPA provided inaccurate cost estimates for regulating the 20 special wastes, one commenter contends that, although EPA ignores many of the costliest elements of the subtitle C program, the Agency's economic analysis accurately demonstrates the high cost impacts of regulating Bevill wastes under subtitle C.

In its analysis, EPA employed an engineering design model and detailed cost analyses to develop realistic cost estimates of subtitle C regulation. After review of the comments and upon further analysis, EPA continues to stand by its cost estimates (as modified) as adequate and appropriate for their intended use as input to the regulatory determination, even though some cost considerations were excluded from the analysis for most wastes (e.g., corrective action). Furthermore, EPA notes that high costs alone are not determinative of appropriate regulatory status. Rather, the financial impact of such costs is the real measure of economic feasibility. Section F below provides additional comments on economic impacts.

6. *Maximum Flexibility.*

One commenter asserted that EPA should calculate subtitle C-Minus compliance costs on the basis of a realistic level of flexibility under RCRA section 3004(x) rather than on the maximum level of flexibility. Unless the maximum flexibility rules can be guaranteed, contends this commenter, firms may be faced with the unpalatable choice of investing in "maximum flexibility" waste disposal facilities in year one, only to find that they need "full subtitle C" facilities in year three.

As was clearly stated in the RTC, the purpose of EPA's evaluation of three regulatory scenarios was to demonstrate the range of potential compliance costs, not to articulate a new regulatory program (which was beyond the scope of the RTC). The Agency believes that using a hypothetical subtitle C-Minus scenario is appropriate for considering the feasibility of subtitle C regulation of special mineral processing wastes, because of the significant technical challenges that stringent regulation of special wastes (by definition) may pose. Moreover, the Agency believes that the "realistic" level of flexibility that may in fact be appropriate needs to be determined based on a detailed evaluation of site-specific conditions, which was not possible within the context of the RTC because of data limitations.

7. *Relative Costs of subtitle C, C-Minus, and subtitle D-Plus.* Several comments were submitted to EPA regarding the relative costs of the subtitle C, C-Minus, and subtitle D-Plus regulatory scenarios. Many of those who commented, recognizing the different cost implications of each scenario, encouraged a subtitle D determination, while others argued that because the differences in estimated costs among the scenarios for certain wastes are insignificant, a subtitle C determination should be promulgated. One commenter argues that with little cost difference, a subtitle C determination would offer greater environmental protection advantages. Another commenter stated that the differences between subtitle C-Minus and subtitle D-Plus regulation are likely to be especially apparent with respect to corrective action costs (which EPA did not include) because inclusion of the processing wastes under subtitle C-Minus may expose the facilities to the same corrective action requirements (and costs) as those under full subtitle C. This same commenter added that non-hazardous wastes should not be regulated under subtitle C (through application of corrective action) simply because such regulation is projected by EPA to be only slightly more costly than subtitle D regulations.

EPA responds that the cost of alternative management practices is but one of the study factors that EPA is required to consider; therefore, the regulatory determination is not being made on the basis of the comparative cost difference between subtitle C and D programs alone. The Agency does recognize that similar corrective action requirements might be applied under both subtitle C and C-Minus, and has examined the associated costs (as discussed above).

In addition, EPA notes that the regulatory scenarios that were used to estimate potential compliance costs were developed with consideration of the environmental protection that they would afford. Thus, it is not the case that subtitle C regulation necessarily would provide more environmental protection that the other scenarios considered. For example, in some cases, adequately protective design and operating standards for new waste management units under subtitle C-Minus and D-Plus have been defined by EPA to be identical.

F. Estimation of Economic Impacts

1. *Inaccurate Use of Price Data.* One commenter identified a specific concern

with EPA's use of estimated mineral prices in 1995, with no explanation as to how they were derived other than that they were reported by an EPA subcontractor. This commenter claimed that EPA did not verify its data by contracting industry sources.

Contrary to the commenter's claim, the Agency used industry experts retained for this purpose to estimate projected 1995 prices. Industry and affected facility input and review prior to the publishing of the RTC were not possible because of procedural constraints. Affected parties were, however, encouraged to review the RTC estimates during the public comment period. In response to comments received, EPA has in fact made corrections to the prices reported in the RTC for refined lead and merchant grade phosphoric acid, which had resulted from calculation and transcription errors; estimated impacts on the corresponding facilities and sectors have been revised in support of today's regulatory determination. As no alternative long-term price projections were suggested by commenters for the remaining primary mineral commodities, estimated long-term real prices remain as reported in the RTC.

Furthermore, the Agency notes two points that reduce the importance of the use or accuracy of the 1995 projected prices. First, while the prices are important in assessing the overall magnitude of the economic impacts, their accuracy will not greatly affect the difference between or relative impacts of subtitle C versus D regulation; that is, the magnitude of the impacts will be affected to a far greater extent than the relative differences between scenarios. Second, if the prices as used are potentially underestimated (in many cases, estimated 1995 prices are lower than current prices), the impacts in the RTC are overestimated because the estimated value of shipments (price multiplied by production quantity) would be smaller and the cost as a percentage of value of shipments, therefore, larger. This is the case for the majority of the sectors, and is consistent with EPA's objective of performing a conservative and defensible analysis. Only in the titanium tetrachloride sector were prices projected to increase significantly, raising the possibility that EPA's estimated value of shipments was overstated and the impacts on that sector were, therefore, underestimated. However, given the strength of that sector (as evidenced by the planned construction of several new domestic plants), EPA believes that the long-term projection of prices for that sector are reasonable and that impacts are not significantly understated.

2. *Impact on Industry.* Several commenters argued that industries producing primary copper, lead, zinc, and elemental phosphorus would be adversely affected by a subtitle C regulatory determination because the regulations would generate additional and substantial annual fixed costs that would have to be met regardless of market conditions. Several of these commenters argued that these costs are likely to remain fixed even in periods of slack demand, contributing to depressed profits during such periods. A few of these commenters further argued that a decreased profit margin would make the market less desirable to investors, thereby discouraging the overall economic growth of the industry.

EPA recognizes that increased costs that cannot be passed along reduce profits at all times, irrespective of market conditions. The costs of adequate environmental protection are, however, simply a component of the total cost of doing business. In trying to evaluate future trends and market conditions, the Agency did conduct qualitative analyses of sectors for which it believed the industry was subject to potentially significant compliance costs, and included the results of these analyses in the RTC. For example, the impacts discussions for the copper, ferrous metal, lead, phosphoric acid, titanium tetrachloride, and zinc sectors included examinations of both the present and future general competitive position of domestic producers, and the potential for compliance cost pass-through (discussed more fully below). EPA believes that its discussion of future trends and market conditions has adequately addressed the concerns regarding long-term impacts.

3. *Pass-Through Potential.* Several commenters indicated that EPA should not assume that the mineral processing industry can pass on the costs of new regulatory requirements to the product consumer in the form of higher prices. A few of these commenters noted that the world market sets the commodity prices; if American producers raise their prices, consumers will look to international markets, where products could be obtained at lower prices. These commenters agreed that higher pricing on mineral processing products could be devastating to the industry.

EPA understands that higher prices in any market can cause adverse impacts on the affected industry. EPA believes, however, that the commenters' suggestions that all mineral processors in all commodity sectors are "price takers" having no ability to pass on cost increases and therefore having to absorb them internally, is demonstrably untrue.

In general, the pass-through of compliance costs follows the path of least market resistance. Where all facilities in the affected sector face similar compliance costs and produce commodities for which there are few alternative supply sources or substitute materials, there is a high likelihood that moderate compliance costs can be passed forward in the form of higher product prices. On the other hand, where only a small proportion of facilities in a sector are affected, or alternative supplies or substitute materials are abundant, the opposite may be true. Similar possibilities exist in input and labor markets where the regulated sector may be able to negotiate wage or price concessions in order to remain in operation or continue operating at current levels. In all cases, the ability to pass through compliance costs depends on the initial incidence of compliance costs within the affected sector and the concentration and interdependency of buyers and sellers in relevant input and product markets. In the RTC, EPA discussed the market factors that, in combination, determine the extent to which regulatory compliance costs can be passed through for each affected commodity sector. In general, EPA found little substantive information or data in the comments received that suggested that the Agency's preliminary findings with respect to pass-through potential were incorrect.

II. Decision making Methodology for the Regulatory Determination

One commenter argued that EPA's second approach, which recommends that the Agency not regulate any of the wastes studied in the RTC as hazardous because of the potential for improved state mineral processing programs, is not authorized by the statute, is factually insupportable, and unlawful, adding that the authority for EPA's second approach does not arise from the study factors in section 8002(p) of RCRA and that EPA's regulatory determination must be directed by the specific provisions of the Bevill Amendment. This commenter further argued that states cannot regulate mineral processing wastes adequately without a national hazardous waste designation, stating that there are no federal programs for nonhazardous waste in place and no statutory authority to ensure that state nonhazardous waste programs adequately regulate mineral

processing wastes. This same commenter stated that EPA's assertions in the RTC about the success of individual state mineral processing waste management control efforts are uncertain and impossible to assess at the present, and therefore cannot support the use of EPA's second approach. In addition, this commenter stated that by delaying regulatory action with EPA's second approach, EPA would substantially undermine the two principal objectives of RCRA: Overall protection of human health and the environment and the minimization of generation and land disposal of hazardous waste. Finally, the commenter argued that if the Agency decides to consider factors beyond the eight listed in section 8002(p), then it must consider all objectives and goals of the RCRA statute, not just a select few.

On the other hand, several commenters encouraged EPA to apply Approach 2 to its regulatory determination, stating that the development and maintenance of strong state programs and federal regulations under other statutory authorities is, in fact, mandated by RCRA. These commenters further argued that the flexibility offered by Approach 2 for regulation of the mineral processing industry is essential to its continued strength and growth, which the Bevill Amendment was enacted to ensure. Other commenters argued that the "other factors" discussed for Approach 2 were, in fact, embodied in the study factors and should be considered in Approach 1.

As was stated in section II of this preamble, EPA generally agrees that its regulatory determination should be based on the eight study factors outlined in section 8002(p) of RCRA, as embodied in the Report to Congress, as well as the public comments and additional information received in response to the Report (and developed by EPA to supplement the Report in response to comments). EPA also agrees that, to the extent that the Agency were otherwise to conclude that subtitle C regulation was warranted based upon consideration of all of these factors and information, that it would be improper to look outside the Report to Congress, public comments, and supplemental technical information to justify a different determination. Therefore, EPA has decided not to employ Approach 2 as outlined in the Report to Congress in making today's regulatory determination, and has instead employed an Approach 1 methodology (modified slightly, as discussed in the main text).

EPA also agrees somewhat with commenters who asserted that the so-called "additional factors" upon which Approach 2 was based are, in large part, already embodied within the contours of the inquiry that Congress intended for EPA to make in the Report and regulatory determination. The Report identifies (1) the development and maintenance of strong state mining and mineral processing regulatory programs, and (2) the facilitation of an integrated federal mining regulatory program as the key considerations under Approach 2. Section 8002(p)(5) instructs EPA to consider "alternatives to current disposal methods" as a factor in developing the Report and regulatory determination. Certainly, consideration of alternative state regulatory schemes, in addition to federal schemes, is contemplated by this section. In addition, facilitation of a potential integrated federal mining program was actually considered by EPA in its cost estimates (reflected in the "subtitle D-Plus scenario").

Nonetheless, EPA does not believe that it should rely on possible improved state programs to determine that subtitle C is not warranted unless EPA is confident that such programs are being developed and can address the problems associated with mineral processing wastes that may pose a significant risk. Thus EPA disagrees that section 8002(p) requires EPA to consider these factors in any way that would supplant a decision the Agency makes under the decision making methodology outlined in Approach 1.

In any event, EPA notes that the issue is effectively moot. As discussed in the section III of this preamble, EPA has been able to make its regulatory determination for all 20 wastes on the basis of a slightly modified Approach 1 alone. Subtitle C was found not to be warranted for any of the wastes analyzed. Thus, even if EPA were to employ Approach 2 as originally conceived in the Report, it would not change any of the decisions made today.

III. Wastes for Which Regulation Under RCRA Subtitle D is Generally Supported

Nine of the twenty special mineral processing wastes studied in the Report to Congress were found to pose few if any risks to public health or the environment. EPA tentatively recommended a subtitle D regulatory determination for these wastes in its Report and continues to believe that subtitle C regulation is unwarranted. The Agency received no comments on the Report suggesting a contrary position. The nine wastes include: (1) Red and brown muds from bauxite refining; (2) gasifier ash from coal gasification; (3) process wastewater from coal gasification; (4) slag tailings from primary copper processing; (5) fluorogypsum from hydrofluoric acid production; (6) treated residue from roasting/leaching of chrome ore; (7) process wastewater from primary magnesium processing by the anhydrous process; (8) basic oxygen furnace and open hearth furnace slag from carbon steel production; and (9) iron blast furnace slag. Therefore, the Agency is today finalizing its decision, as proposed in the RTC, for these nine wastes.

IV. Wastes for Which the Regulatory Determination is Contested

EPA received numerous comments regarding the Report's recommended regulatory determination for 11 wastes: (1) Slag from primary copper processing; (2) slag from elemental phosphorus production; (3) air pollution control dust/sludge from iron blast furnaces; (4) air pollution control dust/sludge from basic oxygen furnaces and open hearth furnaces from carbon steel production; (5) phosphogypsum from phosphoric acid production; (6) process wastewater from phosphoric acid production; (7) slag from primary zinc production; (8) calcium sulfate wastewater treatment plant sludge from primary copper processing; (9) process wastewater from hydrofluoric acid production; (10) slag from primary lead production; and (11) chloride process waste solids from titanium tetrachloride production. As discussed in section I.C.3 of this preamble, the Report tentatively recommended, based on decision making Approach 1, that the first seven of these wastes be regulated under subtitle D, while the last four be regulated under either subtitle C or D, depending on the scenario modeled.

The comments focused on the Report's analysis of the section 8002(p) study factors for each of these wastes, as well as the Report's tentative conclusions. EPA received at least one comment arguing that subtitle C regulation of each of the 11 wastes is warranted. The Agency has considered each of the comments it received, sometimes conducting additional analyses in response, and all of the comments and additional information have been taken into account in developing this final regulatory determination. EPA's responses to these comments are in the supporting comment-response background document.

Appendix B—Analysis of and Response to Public Comments on the Notice of Data Availability

I. Engineering Feasibility and Cost of Alternative Management Practices for Phosphogypsum and Process Wastewater From Phosphoric Acid Production

A. Subtitle C-Minus and D-Plus Scenarios as the Basis for the Regulatory Determination

Twenty commenters questioned the appropriateness of using the Subtitle C-Minus and D-Plus scenarios as a basis for the regulatory determination. Specifically, the commenters contend that because these two scenarios are hypothetical and because regulatory requirements for the scenarios have not been established, the two scenarios cannot be used as a basis for a regulatory determination, and costs estimated for these two scenarios cannot be used to make a decision as to whether or not regulation under the existing subtitle C program is warranted. Furthermore, the commenters believed that the Agency assumption (and cost estimates resulting from that assumption) that certain sub-scenarios for management of process wastewater and/or phosphogypsum would be identical under a C-Minus scenario and a D-Plus scenario is illogical. The commenters concluded that EPA must make its decision between the subtitle C and subtitle D programs and not on variations (i.e., C-Minus and D-Plus) of the two programs.

EPA disagrees with these comments. Section 3004(x) of RCRA allows the Administrator to modify certain subtitle C requirements, *at his discretion*, so as to "take into account the special characteristics" of the wastes in question. Such modifications are "hypothetical" and have not been "established" to the extent that to date, none of the special wastes to which section 3004(x) applies have been regulated under RCRA subtitle C. As discussed at length in the RTC, the Subtitle C-Minus scenarios articulated in the RTC and in the Supplemental Analysis represent realistic (though maximal) application of the regulatory flexibility provided by the statute. The Agency has provided cost estimates for implementation of section 3004(x) flexibility because it believes that a tailored subtitle C program is less costly and may be less burdensome to industry so as to address the risks posed by phosphoric acid industry special wastes. The Agency recognizes that the contours of a prospective subtitle D program for mineral processing wastes have yet to be established. Nonetheless, EPA believes that for analytical purposes, it was appropriate to consider one possible approach to such a program, to estimate the costs and impacts that would result from implementation thereof, and to compare these estimates to those of the other regulatory scenarios, in order to develop an understanding of the potential differences between environmentally protective approaches to special wastes management under the provisions of the two potentially applicable portions of the RCRA statute. Finally, the fact that, in the Agency's view, adequately protective tailored approaches to waste management under subtitle C and subtitle D are very similar in terms of requirements and their costs does not in any way invalidate EPA's analysis. Rather, this suggests only that: (1) Current management controls are inadequate in some cases (as discussed at length in the RTC and elsewhere in today's notice, (2) that even under a Subtitle D program, certain site conditions and waste management practices (such as are found at many phosphoric acid plants) would require fairly stringent controls and changes in current practice to adequately protect the environment, and (3) that the flexibility afforded by section 3004(x) can be employed to develop management standards that are achievable while also ensuring protection of human health and the environment.

B. Technical Feasibility of Engineering Alternatives

The Agency received comments on several aspects of the feasibility of the engineering alternatives (discussed in the NODA). Several of the comments are summarized below; the remainder are addressed in the supporting comment response background document.

1. Use of Undemonstrated Technologies. Several commenters objected to EPA's presentation of engineering alternatives that incorporate certain technologies that are considered by the industry to be undemonstrated, unproven, and/or experimental. The commenters contend that waste management scenarios that utilize undemonstrated technologies cannot be used as alternatives to current waste management practices under the definition of section 8002(p) of RCRA. The commenters contend that each of the "Subtitle C compliance scenarios" (Engineering Alternatives 1, 2, and 7) incorporate one or more technologies that are not currently demonstrated in the industry as feasible. These technologies include the following:

- Segregation (hydraulic separation) of waste management units for process wastewater and phosphogypsum (Alternatives 1, 2, and 7);
- Neutralization of phosphogypsum slurry, disposal of limed gypsum on existing stacks, and return of transport water to the production process (Alternatives 1, 2, and 7);
- Recovery of fluosilicic acid from the reaction stage of phosphoric acid production (Alternatives 2 and 7); and
- Use of cooling towers and indirect cooling via heat exchangers to effect a closed-loop cooling system in lieu of a process wastewater cooling pond.

As an example of undemonstrated technology, the commenters stated that even though lime neutralization of process wastewater is used at some plants before NPDES-permitted discharge, neutralization of all process wastewater and subsequent recycle to the production process has not been successfully demonstrated at an existing plant. Because this technology and the other technologies are undemonstrated in the industry in the manner in which they are intended to be used in the engineering alternatives, the commenters argued that the subtitle C engineering alternatives cannot be used as a basis for a regulatory determination to regulate the industry under subtitle C.

EPA largely disagrees with these comments. The commenters' proposed definition of "demonstrated" is extreme and contrary to long-standing Agency policy. While EPA agrees that there must be an expectation that a given technology will perform adequately if it is to serve as the basis for a regulatory decision, the Agency does not agree that current use of the technology in the industry being examined is necessary. In fact, it is very often the case that technologies and techniques that have been developed elsewhere for different purposes are used by the Agency for achievement of new pollution control standards. This type of "technology transfer" is at the very heart of such programs as Clean Water Act Effluent Guidelines development and establishment of Best Demonstrated Available Technology (BDAT) requirements under the RCRA Subtitle C Land Disposal Restrictions.

With regard to the specific technologies that comprise engineering alternatives 1, 2, and 7, EPA believes that most, if not all, of these technologies have been demonstrated in other industrial applications and that their technical feasibility is not in question. The fact that they are not in

use in the phosphoric acid industry is more reflective of an absence of strong regulatory controls and associated financial incentives than of the feasibility or availability of the technologies themselves. Specifically, EPA has at least anecdotal evidence that closed loop cooling and recovery of FSA from the reactor/flash cooler system have been successfully employed in other industries and in foreign phosphoric acid plants, respectively.

Moreover, EPA wishes to make clear that it believes that the commenters have misinterpreted the Agency's response to the statutory requirement to examine "alternatives to current disposal methods" and "the costs of such alternatives" (RCRA section 8002(p), study factors 5 and 6). As pointed out by the commenters, in the RTC, EPA discussed a number of alternatives to current waste management practices, focusing on techniques that have been applied on a commercial scale to reduce the quantity and/or toxicity of the special wastes considered in the Report. The intent of this discussion was to achieve *partial fulfillment of study factors 5 and 8 (potential utilization) by focusing on proven* means of source reduction and waste minimization as an alternative to on-site waste management. For most of the 20 special wastes considered in the RTC, opportunities for recycling and commercial use are quite limited, for various reasons. In contrast, EPA's approach to responding to the remainder of study factor 5 as well as study factor 6 was to articulate and estimate the costs of on-site waste management under alternative *regulatory* scenarios. The Agency believes that this context was and is the most relevant to the key decisions to be made (Subtitle C vs. Subtitle D regulation) based upon the findings of the RTC and subsequent analysis. Thus, there is no direct linkage between EPA's criterion for discussion of a waste management alternative or opportunity for utilization and the development and analytical implementation of the regulatory scenarios presented in the RTC and the Supplemental Analysis. Accordingly, EPA categorically rejects the commenters' assertion that a given technology, device, and/or practice must currently be in use within the domestic phosphoric acid industry in order for it to be considered "technically feasible." The Agency further rejects the commenters' suggestion that EPA's own methodology as articulated in the RTC compels such an approach, because commenters have misconstrued the Agency's analytical methods and underlying rationale.

The Agency acknowledges that there are significant uncertainties regarding the operational consequences of the lime treatment of phosphogypsum. Once again, however, commenters have based their arguments upon an inaccurate interpretation of EPA's analysis. The treatment of phosphogypsum contemplated in engineering alternatives 1, 2, and 7 assumes that the water being used to slurry the gypsum from the filter to the neutralization mixing basin would be *treated* process wastewater, not the "pond water" that is currently managed at active facilities.

Consequently, the laboratory test results reported by the commenters in support of their argument are, in the Agency's view, of questionable relevance, and by no means demonstrate that treated gypsum would present significant disposal and other operational problems.

Finally, EPA believes that the importance of the issue of segregation of the gypsum management and cooling water areas within a facility's waste management system has been overstated by the commenters. In the Supplemental Analysis, EPA discussed a number of different approaches for separately addressing contaminants contained in phosphogypsum slurry and contaminants condensed into cooling waters. In no case did EPA state (or even suggest) that a complete hydraulic separation between gypsum management units and cooling ponds would be either necessary or appropriate, even under a full subtitle C scenario. Indeed, the Supplemental Analysis recognizes that leachate will continue to be generated for many years from any existing gypsum stack. To the extent that this leachate or gypsum transport water (which would have been rendered non-hazardous under engineering alternatives 1, 2, and 7) might enter the cooling water pond, treatment or product recovery would occur through removal of this water to the treatment system or filter, respectively. In either case, "co-mingling" of separate hazardous wastes would not occur, obviating the need for complete hydraulic separation and any associated undesirable effects on plant water balance.

2. Feasibility of Lime Neutralization. Several commenters expressed doubt over the engineering feasibility of lime neutralization of both process wastewater and phosphogypsum, for several reasons, including the limited availability of lime to meet the demand that would be created and the formation of a silica gel that would interfere with waste management and production process operations.

Several commenters argued that the demand for lime imposed by any of the engineering alternatives that incorporate lime neutralization would place a severe burden on the United States lime production industry. The commenters stated that implementation of Engineering Alternative 1 (lime neutralization of all waste streams) would require the southeastern lime industry to triple its present capacity in the first year of implementation of the alternative to meet the additional demand. In addition to expressing their uncertainty over whether this demand could be met, the commenters also expressed concern over potential environmental impacts that the demand would create, including increased generation of carbon dioxide, increased fuel consumption, and the need for additional limestone strip mines.

In response to this comment, EPA has conducted additional analysis to determine whether implementation of Alternative 1 would impart significant impacts on lime supply, demand, and capacity within the relevant regions of the country. A description of this analysis and the results thereof may be found in the docket.[1] These results suggest several conclusions.

First, EPA agrees that adoption of engineering alternative 1 by the entire domestic industry would significantly increase the demand for lime in the regions of the country in which the active phosphoric acid plants are located, requiring an increase in lime production. In the western states (Idaho and Wyoming), this increase could probably be met through greater utilization of existing lime production capacity. In the south, uniform adoption of engineering alternative 1 would create demand in excess of regional supply, requiring shipments from other parts of the country (e.g., Ohio, Pennsylvania), installation of additional lime capacity, and/or imports of lime (probably from Mexico).

Second, the analysis of incremental lime demand presented by the commenters significantly overstates the impacts of new regulatory requirements, for several reasons. The estimates of lime demand presented by the commenters are substantially higher than EPA's estimates. Because the

[1] ICF Incorporated. 1991. Technical Background Document: Data and Analyses in Support of the Regulatory Determination for Special Wastes from Phosphoric Acid Production. Prepared for the Office of Solid Waste, US EPA.

reasons for this difference have not been adequately explained in the materials submitted to the Agency, EPA continues to believe that its lime consumption estimates for engineering alternative 1 are valid. Moreover, in comparing demand with supply, commenters were quite selective in terms of which states and lime plants were defined as being located within the same region as the phosphoric acid plants. EPA believes that lime produced in Virginia, Kentucky, Illinois, Indiana, Missouri, and Texas is also available (in a logistical and economic sense) to the potentially affected phosphoric acid facilities, particularly those located in Louisiana, Texas, and North Carolina. Therefore, the gap between potential demand and existing supply is substantially narrower than that suggested by the commenters.

Third, the Agency acknowledges that implementation of any alternative that substantially increased the demand for lime would result in increased energy consumption and releases of carbon dioxide, a "greenhouse" gas, to the atmosphere. Because many lime and limestone producers are operating at levels substantially below their capacity, however, EPA is not convinced that opening of additional limestone mines would necessarily be required to any significant degree as a result of implementation of the engineering alternatives, though additional production from existing mines would clearly be needed.

Finally, and most importantly, the comments focus on a worst-case scenario under which every plant would lime treat all of its special wastes. Under a tailored subtitle C (C-Minus) program, this is but one option among many. EPA believes that most facility operators, when provided with the incentive to comply in a least-cost manner, would develop alternatives to lime treating all of their wastes, thus greatly reducing the amount of lime required and the importance of this issue.

Commenters also stated that a colloidal silica gel would be created during the neutralization of process wastewater and phosphogypsum. The commenters argued that this gel is likely to remain in suspension in both the gypsum transport water and the cooling pond process wastewater, which may pose significant problems in the operation of plant equipment when these waters are returned to the production process. In particular, several commenters stated that the gel would potentially "blind" (clog) the phosphogypsum filter when the treated gypsum transport water is returned to the filter and reused as filter washwater, resulting in decreased efficiency, increased downtime, and lost production. Commenters also indicated that they were unaware of any demonstrated technology to remove the gel from the phosphogypsum filters.

EPA is not convinced that the catastrophic operational effects predicted by the commenters would occur on a widespread and continuing basis if lime treatment of the special wastes were to be instituted, particularly if FSA recovery were to be practiced. Commenters have assumed that the engineering alternatives contemplated by EPA would involve continual treatment of process wastewater and phosphogypsum as they are *currently* generated, when in fact the alternatives were developed to address management of new waste streams having different chemical characteristics resulting from treatment and/or product recovery. Therefore, the appropriate question is whether lime treatment of process wastewater that has *not* reached a high equilibrium concentration of chemical contaminants would result in significant gel formation, not whether lime treatment of currently generated "pond water" would create such operational problems.

Nevertheless, EPA does have some concerns about the efficacy of a lime treatment strategy. For example, the Agency recognizes that for a period of time (perhaps one to two years), treatment of existing pond water would occur. To the extent that gel formation took place, operational difficulties might be significant. Because, however, implementation of today's decision does not require that lime treatment be implemented, EPA does not believe that resolution of this issue (which would require additional research) is necessary prior to a determination of the appropriate regulatory status of the special wastes from phosphoric acid production.

3. Feasibility of Separate Management of Phosphogypsum and Process Wastewater. Commenters expressed concern over the technical difficulty inherent in separately managing phosphogypsum and process wastewater so that no hydraulic communication between the two "circuits" is permitted. Because the integrated management of these two wastes is employed at all existing facilities and is, according to the commenters, essential to maintaining a negative water balance (i.e., zero discharge through NPDES outfalls), the commenters believed that the separate management of these two wastes is an undemonstrated technology that cannot be used to support a regulatory determination. One commenter performed a computer modeling study to predict his facility's water balance under Engineering Alternatives 1 and 7 and predicted that separate management of process wastewater and phosphogypsum at the facility would require treatment and discharge of excess process wastewater. Commenters indicated that the potential increase in discharge created by segregated management would be contrary to the objectives of the Clean Water Act effluent guidelines as well as NPDES requirements for the industry. Furthermore, the commenters pointed out that the Agency addressed neither the feasibility nor the cost of implementing separate management of the wastes.

As discussed above, the Agency has never suggested that it would require complete hydraulic separation of the areas dedicated to gypsum disposal and process water cooling. In addition, the computer simulation results submitted by the commenter assume no changes or adjustments in the operation of the plant, an assumption that is contrary to standard industry practice. Plants continually monitor water balance and modify their water management activities as needed to comply with discharge limits and operational requirements. EPA has received no convincing evidence that suggests that a new water balance could not be developed for affected plants, though admittedly, new equipment and piping might be necessary in some situations. Accordingly, EPA believes that the potential impacts on plant water balance and associated regulatory significance of the issue as suggested by the commenters are substantially overstated.

4. Land Required To Implement Subtitle C Compliance Alternatives. Some commenters contend that adequate amounts of land are unavailable to implement the subtitle C compliance alternatives (Alternatives 1, 2, and 7); hence, the commenters stated that implementation of these alternatives under subtitle C is infeasible. The commenters contend that the implementation of these alternatives would require the construction of new waste management and treatment units and expansion of existing waste management units on land that is in addition to acreage already occupied at the facilities. Specifically, the commenters stated that in order to implement Alternative 1 (lime

neutralization of all waste streams), additional land would be required for: (1) Extra filter capacity; (2) lime receiving and slaking facilities; (3) a 50-acre gypsum transport water pond; (4) an additional 50 acres of cooling ponds; (5) a cooling water neutralization basin; (6) a larger stack; and (7) cooling water sludge ponds. Many of the facilities that commented claimed that they did not have enough land available to accommodate all of these units, and many of these facilities reported that they could not purchase adjacent property of sufficient size.

EPA continues to believe that the availability and cost of land needed for regulatory compliance are not critical issues. As discussed in more detail below, the Agency believes that the commenters' estimates of the size of new required waste management units are significantly overstated. Also, additional land required for many of the items listed by the commenters (e.g., extra filter capacity, lime receiving and slaking facilities, neutralization basin) is quite modest in extent, particularly within the context of the vast scale of a domestic phosphoric acid plant (all of which are hundreds or thousands of acres in size). Moreover, to the extent that substantial new acreage is required for additional waste management units, land could be acquired that was not adjacent to the facility, i.e., the units could be sited at some distance from the plant. EPA believes that the incremental costs of managing the phosphoric acid wastes in this manner would be modest because the wastes are already piped (in slurry and liquid form) considerable distances (hundreds of yards) at some plants. Therefore, the Agency believes that "extending the pipeline," even for several miles, is not a significant issue, from either a feasibility or cost standpoint.

C. Costs of Engineering Alternatives

The Agency received comments on several aspects of the estimated costs of the engineering alternatives. Several of these comments are summarized below; the remainder are addressed in the supporting comment response background document.

1. Operating Year. Commenters argued that EPA significantly understated the costs of the engineering alternatives by basing its calculation of annual incremental compliance costs per ton of P_2O_5 output on a 365-day production year. The commenters contend that it is not possible for phosphoric acid facilities to operate 365 days in a year and that, due to necessary maintenance, facilities operate, on average, 330 days per year.

Data submitted by individual facility operators in EPA's 1989 National Survey of Special Wastes from Mineral Processing Facilities demonstrate that most phosphoric acid plants operated for more than 350 days in 1988. Nonetheless, EPA recognizes that individual production lines within a given plant are subject to considerable down time for maintenance and repairs. Because the model plant used to evaluate the engineering alternatives in the Supplemental Analysis was based on a single production line, the Agency has revised its cost estimates to reflect the commenter's suggestion that a 330 day operating year be employed.

2. Capital Cost for Neutralization Sludge Ponds. Commenters argued that EPA seriously understated the capital cost of installing sludge disposal impoundments necessary to manage the calcium fluoride sludge that would be generated by lime neutralization of the cooling water component of process wastewater. The reasons given by the commenters are:

(1) EPA's capital cost was sufficient for only one year of sludge storage;

(2) The capital cost does not include the cost of acreage needed to provide adequate residence time for settling of solids in the treated cooling water; and

(3) Lining of the impoundment was not included and would be required.

EPA generally disagrees with this comment. The Agency recognizes that it did not provide complete information concerning engineering design assumptions in the Supplemental Analysis; this omission occurred because of extreme time constraints. EPA believes that many of the commenters' concerns arise from incorrect (though, in many cases, reasonable) inferences that they have made based upon the limited information that was available to them. First, the sludge settling/disposal impoundments referred to by the commenter were indeed designed to accommodate a 15 year accumulation of process wastewater treatment sludge. For engineering alternative 1, the impoundment was designed to contain 118,271,000 cubic feet of sludge (generation rate of 7.8 million cubic feet or 180 acre-feet per year). Using the same cost engineering model as employed for the RTC, EPA estimated that this impoundment would cover 64 acres (80 acres total, allowing for site preparation activities), and have a depth of 42 feet (14 foot dug out depth, 28 foot berm height).

Furthermore, as clearly stated in the Supplemental Analysis, the Agency believes that the volume of the sludge disposal impoundment (the vast majority of which would be available in the early years of operation) coupled with the large volume of the existing cooling pond, would provide adequate residence time for solids removal (settling) from the treated process wastewater stream. Commenters have provided no evidence or a rationale supporting their contention that EPA's assumptions in this regard might be invalid; EPA concludes, therefore, that its approach as described in the Supplemental Analysis was and is reasonable. Therefore, the Agency believes that the commenters' suggestion that the actual area required for treated process wastewater and sludge management (1,272 acres versus EPA's estimate of 80 acres) is significantly in error.

Finally, EPA does acknowledge that there is a distinct possibility that the sludge settling impoundments required under Alternative 1 would require composite liners, at least for facilities located in the State of Florida. Florida ground-water protection standards (which incorporate federal MCLs) allow individual permit writers, at their discretion, to require the installation of liners under new units to ensure adequate protection of the ground-water resource. Because the concentrations of lime-treated process wastewater contaminants such as sulfate and sodium are likely to be an order of magnitude or more above MCLs (they are *not* removed to any significant extent by lime treatment [2]), EPA has concluded that liners would probably be required as a permit condition for any CaF_2 sludge disposal impoundment(s) that would be built in Florida as part of a regulatory compliance strategy. Therefore, to the extent that such impoundments would actually be constructed in response to new regulations, EPA has underestimated the associated compliance costs in the Supplemental Analysis.

3. Cost of Separate Management of Phosphogypsum and Process Wastewater. The industry commenters stated that EPA failed to consider the capital costs and operating and maintenance costs involved with separately managing the cooling water and phosphogypsum slurry circuits. The commenters further contend that separate management of these waste streams would necessitate a major retrofit of current waste management units at existing production facilities.

[2] As depicted in the Supplemental Analysis, Exhibit 1, p. 12, and as suggested by numerous additional data submitted to the docket.

The commenters estimated that the cost necessary to separate the gypsum and cooling water circuits (capital cost) at EPA's model plant would be at least $10 million.

As discussed above, the Agency has never stated that it would require complete hydraulic separation of the areas dedicated to gypsum disposal and process water cooling. Accordingly, EPA does not believe that a plant retrofit to achieve separation of these areas would be necessary or required.

D. Economic Impacts of Alternative Waste Management Practices

In general, all of the industry commenters considered implementation of the various alternatives under subtitle C to be economically intractable. Based on their analysis of the economic impacts they believe would be imposed by the implementation of engineering alternative 1, the commenters concluded that: (1) Implementation of the alternative would eliminate the industry's export markets; (2) it is possible that foreign producers could penetrate the domestic market; and (3) incremental compliance costs could not be reasonably passed on to suppliers, workers, or consumers. The commenters believed that these conclusions would apply equally to impacts posed by engineering alternatives 2 and 7.

EPA recognizes that implementation of engineering alternatives 1, 2, and 7 under a subtitle C framework would impose cost impacts that might be difficult for members of the domestic industry to withstand. The real issue, however, is the magnitude and distribution of the impacts that might be imposed by tailored subtitle C standards. Under the Subtitle C-Minus scenario presented in both the RTC and the Supplemental Analysis, facilities could achieve compliance by adopting strategies to either contain or reduce/eliminate contaminants in their special wastes. Presumably, they would do so in a manner that minimized costs, given their own operational strategies and site-specific conditions. Therefore, the cost estimates provided in the Supplemental Analysis should be viewed as upper-bound estimates; it is likely that actual costs and associated impacts would be lower (at least on a per ton P_2O_5 basis) than those estimated for the model plant.[3] This fact, coupled with diminished relevance of the cost impacts of full subtitle C regulation, suggests that many of the claims made by commenters are overstated.

II. Other Wastes Addressed in the Notice of Data Availability

EPA received no comments on the additional information regarding gasifier ash and process wastewater from coal gasification. However, the Agency did receive two comments addressing the supplemental analysis of basic oxygen furnace dust/sludge from carbon steel production. The Agency has taken the comments into account in developing this final regulatory determination. EPA's detailed responses to the comments are available for inspection in the docket.

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[3] While this is true, estimated costs under the Subtitle D-Plus scenario are also very high.

Risks Posed by Bevill Wastes

Environmental Protection Agency

1997

Introduction

Based upon information on potential and actual environmental threats and the availability of new risk assessment techniques, the Agency is seeking comment on whether reexamination of some Bevill waste is warranted. In this report, the Agency is providing the most current information available on the environmental risks associated with mining and mineral processing operations. The Agency is presenting new information on risks posed by Bevill wastes and is posing the question of whether some waste streams require additional study or regulatory controls given the availability of new risk assessment techniques. Conversely, the Agency is also soliciting comment on whether more protective environmental practices have been put in place and, if so, whether future regulatory actions are necessary.

Background

When Congress excluded mining wastes from RCRA Subtitle C regulations (the Bevill Amendment of 1980), it gave the Agency directions to study these wastes and determine which ones should remain exempt from RCRA Subtitle C regulations. On December 31, 1985, EPA published the required Report to Congress on Solid Wastes from Mineral Extraction and Beneficiation[1], and on July 3, 1986 (51 FR 24496) published a determination that regulation of certain mining wastes under Subtitle C of RCRA was not warranted, primarily because traditional hazardous waste controls applied to large volume mining wastes may be technically infeasible or economically impractical. In making this determination, Congress required the Agency to consider several factors, including mining waste disposal practices, potential danger to human health and the environment, and the costs imposed by potential regulation of mining waste. See Regulatory Determination, July 3, 1986, 51 FR 2449; RCRA §§ 3001(b)(3)(A)(ii), 8002(f), and 8002(p).

While the Agency determined that Subtitle C regulations were not warranted for extraction and beneficiation wastes, it found that a significant quantity of mining wastes exhibited hazardous characteristics and expressed concerns about environmental damage from mining.[2] Further, the Agency expressed concerns about other hazardous properties of mining wastes such as, radioactivity, asbestos, cyanide, or acid generation potential, that is not identified by the current RCRA characteristics. 51 FR 2449.

The Agency similarly studied mineral processing wastes, exempted 20 large volume special wastes, and likewise expressed concern about actual and threatened environmental

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[1] EPA No. 530-SW-85-033

[2] 51 FR 24496, July, 1986 1.3 to 2 billion metric tons of nonfuel mining waste were generated annually. 755 million metric tons of mining waste had RCRA hazardous characteristics or were potentially subject to RCRA. Mineral processing facilities generated approximately 500 million metric tons annually. By comparison, in 1993 large quantity generators (industries subject to Subtitle C regulations) produced 258 million tons of hazardous wastes.

damages caused by some of these wastes[3]. For at least two of the 20 special wastes, the Agency went so far as to recommend potentially pursuing a regulatory program under the Toxic Substances Control Program and the option of revisiting Subtitle C controls. 56 FR at 27214-16. The Agency found that current phosphogypsum process wastewater management practices are often not adequate to limit releases and associated risks.[4] The Agency pursued further studies and regulatory options and found areas where the toxicity of phosphogypsum wastes could be reduced. However, the costs involved were believed to be prohibitive and the Agency pursued no further regulatory action. (See Phosphoric Acid Waste Dialogue Draft Report on Activities and Recommendations, April 1995).

After studying beneficiation wastes, the Agency expressed concerns about the environmental threats from mining and stated that the Administration will work with Congress to develop expanded Subtitle D authority (i.e., Federal oversight and enforcement) to support an effective State-implemented program for mining waste and use RCRA section 7003 and CERCLA sections 104 and 106 to protect against substantial threats and imminent hazards in the interim. 51 FR 24496. At that time, the Agency believed if it were unable to develop an effective mining waste program under Subtitle D, the Agency may find it necessary to use Subtitle C authority in the future. 51 FR 24496.

As a result of this decision, EPA began to develop a series of alternative mine waste management approaches--so called Strawman I and II released in 1988 and 1990, respectively (Strawman I , USEPA, Office of Solid Waste, May, 1988, and Strawman II, USEPA, Office of Solid Waste, May, 1990). These documents were staff-level products. Strawman II was based primarily on approaches developed by the Western Governors' Association Mine Waste Taskforce. These approaches embraced the idea of a mine waste program tailored to the unique aspects of each state's situation, considering the distinct climatic, geological, and ecological characteristics of each mine. While the Agency received valuable comments on these drafts, it became clear that the level of disagreement was considerable and that face-to-face interaction among the interested parties would be helpful.

In 1991, the states, industry, and the environmental community approached EPA and requested that EPA create a forum to further discuss mine waste issues. In 1991, EPA chartered the Policy Dialogue Committee (PDC) on Mining under the Federal Advisory Committee Act (FACA). The PDC had representatives from the states, the mining industry, the environmental community as well as from the major federal agencies (i.e., Department of the Interior (DOI) and the Department of Agriculture (DOA) and EPA). The purpose of the PDC was to inform the various parties of each others positions and further the debate on development of a national mine waste program. The PDC met seven times and ended in

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[3] Special Wastes from Mineral Processing Final Regulatory Determination and Final Rule, 56 FR 27300, June 13, 1991.

[4] The Agency studied 16 of these phosphoric acid facilities and found that 13 appear to have caused groundwater contamination and 12 have contaminants above primary drinking water standards that have migrated or are likely to migrate beyond the facilities boundaries. 56 FR at 27315.

1992. While the level of disagreement among the parties has narrowed, it has not been mitigated. (A summary of the PDC activities can be found in the PDC White Paper this rule's docket).

Since the 1986 Determination to exclude certain mining wastes, the Agency has been developing various technical documents on improving the management of mining wastes and has given grants to several states to improve existing state mining programs. Despite these activities, the Agency has not established a Subtitle D or any federally enforceable regulatory program for mining or mineral processing wastes excluded by the 1980 Bevill Amendment.

Environmental Damages and Releases from Bevill Exempt Wastes

The Agency continues to believe that mining waste poses a broad range of environmental risk. Some types of mines and waste management practices pose very little risks while others pose significant environmental problems and threats to human health. In contrast to EPA's assertions, mining industry commentors indicate that: most environmental damage cases are representative of past mining practice no longer used; mining and mineral processing poses little, if any, environmental threat, and that state programs adequately regulate modern mines.

The Agency has found that some mining practices are no longer used. However, the Agency's studies also indicate that some currently operating Bevill mining and mineral processing wastes continue to contaminate groundwater and surface water, often through leaking surface impoundments, runoff from piles, wind blown dust, contaminated soil, and failure of dams. Further, the environmental consequences of mining and mineral processing may not be realized until long after cessation of operations, as indicated by the growing list of mine and mineral sites being addressed under the CERCLA Superfund program. When EPA studied mining wastes in 1985, there were 18 mine sites on the National Priorities List (NPL). Currently, there are over 60 NPL sites where the source of contamination is primarily caused by practices that continue today. (See Mine and Mineral Processing Sites on the NPL, EPA, 1997). For example, some tailing ponds and waste rock piles from both historic and currently operating mines are causing environmental damage from acid mine drainage. Further, of the 60 sites on the NPL, more than one-half have been active at some point since 1985, indicating that at least some of the problems are attributable to modern practices. The approximate cost of remediating mining sites currently on the NPL is $20 billion. Based on studies conducted by the Western Governors Association, EPA believes that there are approximately 200,000 abandoned mines in the U.S. It is probable that ten percent of those sites (20,000 abandoned mines) are causing some degree of environmental harm, according to studies performed by the National Park Service. There are no accurate cost estimates for remediating abandoned mines which are currently causing serious environmental harm. However, the Agency and the U.S. Forest Service have determined that mining practices caused contamination of over 10,000 miles of streams throughout the US.

The Agency has also had to take action at an additional 72 mines and mineral processing sites where contamination posed an imminent threat to human health and the

environment. Section 106 of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) provides for abatement action by a State, local government, or the President, when there exists an "imminent and substantial endangerment to the public health or welfare or the environment because of an actual or threatened release of a hazardous substance." In addition, Section 106 contains penalties for noncompliance, forcing potentially responsible parties to clean up a site, or pay as much as $25,000 a day. These orders are one of EPA's enforcement tools, which achieve cleanup at sites posing significant threat to human health and the environment where negotiations over Superfund cleanups have failed.

Review of these imminent threats cases indicate that mining and mineral processing activities continue to pose significant threats not only while operating but long after the cessation of operations. This may occur to failure of dams or impoundments, accumulation of wind blown dust, movement of contaminated soil, generation of acid through weathering, and periodic releases of toxic chemicals. At many of the sites, the greatest area of concern is direct human exposure, ingestion, or inhalation of contaminants. (EPA studied hazardous substances present in dust at mines sites in a report titled "Summary of NIOSH Bulk Dust Metals Data, 1991.") Many of the site actions are time critical, meaning that action had to be taken before site conditions became worse. Also, many practices that gave rise to the actions, such as storage of toxic chemicals and wastes, are similar to practices that occur at operating mines. This information is presented in the technical background document "CERCLA Imminent Hazard - Mining and Mineral Processing Facilities, EPA, 1997."

In addition, there are many more documented cases from operating mines and mineral processing sites that have either actual or threatened groundwater, surface water, or soil contamination. A number of environmental damages from mining were identified in the Agency's 1985 Report to Congress. EPA continued to study environmental damages from mining and in 1994 published a report "Mining Waste Releases and Environmental Effects Summaries for Idaho, South Dakota, New Mexico, South Carolina, Nevada, Montana, Colorado, Arizona, and California, EPA, March 1994". This 1994 report collected environmental release information on operating mines found in publicly available files maintained by state agencies. The report was based on data collected from 1986 to 1991. The Agency found that operating mines were releasing cyanide, acids, tailings, dusts, and other materials containing hazardous substances into the environment.

EPA continued to collect additional environmental release information on operating mines for the period 1990 to present (See Damage Cases and Environmental Releases, EPA, 1997). The mining industry, in comments on the January 25, 1996 proposal, contend that earlier environmental release information did not accurately reflect activities at modern operating mines. However, in addition to EPA's earlier studies, the 1997 report has also found that operating mines are releasing into the environment the same types of contaminants (cyanide, acids, dusts, radioactivity, and tailings) that the Agency first identified as environmental concerns in its 1985 Report to Congress. The 1997 report also confirmed that environmental releases noted in the Agency's 1994 environmental release state reports are continuing at operating mines. Based on these reports, the Agency concludes that modern mining practices continue to release contaminants and other hazardous substances into the

environment.

In the prior Bevill rulemakings, EPA expressed concern about wastes that may not necessarily exhibit a toxicity characteristic under RCRA yet may pose other types of risks. These include cyanide used in gold mining, acid generating wastes from copper and gold mining, and naturally occurring radioactivity. Since that time the Agency has documented numerous incidents of damage involving these wastes, including modern and operating mines being placed on the National Priorities List and requiring other response and remedial actions. One recent damage case involves the Summitville mine where cyanide and acid rock drainage caused severe environmental damage to nearby streams and rivers (see USGS Report on Summitville). The Summitville mine was built in the 1980's and operated into the early 1990's using waste management practices that are typical of modern gold mining. Additionally, the Agency is concerned about the rising cleanup costs from mines and mineral processing sites. As previously mentioned, EPA estimates the cost of remediation for mines and mineral processing sites proposed and on the NPL to exceed $20 billion. In the above example, the Summitville site cost the Federal government over $140 million in remedial and emergency actions and additional costs are mounting.

In the 1986 Regulatory Determination, EPA expressed concern about the hazards posed by naturally occurring radioactivity materials (NORM) in mining wastes. The Agency conducted a study of waste management practices in the copper industry in 1994 (See Technical Resource Document-Copper, Office of Solid Waste, USEPA, 1994) which noted that several copper mines located in Arizona produced uranium yellowcake by processing copper ore in the 1950's. Agency review of the chemical composition of copper ore indicates that uranium is often found in and around copper deposits. Recent studies indicate that some copper leaching operations may mobilize and concentrate NORM in various wastes streams and process solutions, potentially causing groundwater and surface water contamination. (See Technical Report on Naturally Occurring Radioactive Materials in the Southwestern Copper Belt of Arizona, EPA, 1996).

The 1985 Report to Congress also found that phosphate mining activities (mainly located in Florida) generated wastes which contained radon at levels exceeding 10 picocuries. EPA's Office of Radiation and Indoor Air also recognized the radiation risks associated with the disposal of phosphogypsum. In 1989, EPA issued a National Emission Standard for Hazardous Air Pollutants (NESHAP) applicable to radon emissions from phosphogypsum stacks (See 54 FR 51654, December 15, 1989). This rule required that all phosphogysum be disposed in stacks thereby permitting control and measurement of gaseous radon-222 which is emitted when radium present in phosphogysum decays.

The Agency again studied wastes generated from the production of phosphoric acid in the 1990 Report to Congress on Wastes from Mineral Processing and found that phosphogypsum wastes were causing groundwater contamination and that these wastes contained high levels of radon. In June, 1991 EPA issued its Regulatory Determination (see 56 FR 27300) which indicated that the Agency would review possible regulatory actions under the Toxic Substances Control Act to determine if TSCA could more effectively regulate phosphogypsum and process waste waters. The Agency chartered the Phosphoric Acid Waste Dialogue Committee under the Federal Advisory Committee Act in 1992 to determine if

TSCA could effectively regulate phosphate wastes. This group met six times from 1992 to 1994 (See Phosphoric Acid Waste Dialogue Draft Report on Activities and Recommendations, April 1995). The Committee did not identify any affordable, technologically feasible in-plant process changes that would significantly reduce the volume and/or toxicity of phosphogypsum or phosphoric acid process wastewater. The Agency found therefore that since TSCA regulation would not be possible, the Agency would revisit the 1991 Regulatory Determination and determine whether RCRA Subtitle C regulation of phosphoric acid special wastes remains inappropriate.

As a follow-up to the conclusion of the Phosphoric Acid Waste Dialogue Committee, in 1992 the Agency evaluated the environmental risks posed by the disposal of phosphogypsum at 13 phosphoric acid production facilities in Florida by applying the RCRA National Corrective Action Prioritization System to each site. The results show that all 13 facilities would qualify as "high priority" under the National guidelines by either the composite score or a high individual groundwater or surface water pathway score. This evaluation also noted that there was groundwater contamination at all of the 13 sites.

Phosphate mining also presents other environmental risks associated with failures of clay ponds. When mining phosphate, the overburden is removed, and the phosphate ore is dug up and placed in small pits were it is broken up with water cannons and slurried to the mill. At the mill the phosphate slurry is crushed sized and washed. This process is used to separate the sand and clay from the phosphate ore. The sands are slurried to sand settling basins or it is pumped back into mine cuts. The clays are slurried to clay settling ponds, which often cover hundreds of acres. These ponds are unlined and often use earthen dams to retain water.

In 1971 there was a major failure of a clay pond at the city Services (now the Cargill Fertilizer) mine. That spill dumped more than 1 billion gallons of clay slimes and wastewater into the Peace River. In 1972 the state mandated that all new dams must be built to tougher engineering standards. The state however failed to require existing dams be closed by a fixed date. Therefore the mining companies continue to use their older ponds. IMC-Agrico alone has 17 of the old dams in operation.

Since 1990, there have been five major failures of clay pond dams: 1990 at Gardinier spilled 250,000 gallons into a tributary of the Peace River, 1991 US Agri-Chemicals spilled 175 million gallons into a tributary of the Peace River, 1993 Mobil Mining spilled 2 million gallons into the North prong of the Ajafia River, June, 1994 Imc-Agrico 1.7 billion gallons spill, October 2, 1994 IMC-Agrico spilled 127 million gallons into a tributary of the Peace River, and on October 31, 1994 Cargill Fertilizer spilled 20 million gallons into a tributary of the Peace River. The most recent spill occurred when a clay pond dam burst at the IMC Agrico Hopewell phosphate mine and dumped up to 500 million gallons of clay slime and water.

As noted earlier, the Agency first indicated its concern about environmental contamination from cyanide in the 1985 Report to Congress. In 1994, the Agency found that gold mining using cyanide solutions were causing releases into the environment (See Technical Resource Document-Gold, USEPA, 1994). Superfund cleanup activities at the

Summitville gold mine indicated that cyanide solution leaked into the environment and contaminated the Alamosa River and as much as 10 feet of soil per year. The cost of clean-up at Summitville is estimated at $150 million. The Brewer gold mine in South Carolina experienced a major cyanide spill in 1987 when 10-12 million gallons of cyanide solution flowed into a nearby river. The Agency's most recent review of mining waste releases into the environment (See Damage Cases and Environmental Releases, EPA, 1997) again show that gold mines are releasing cyanide into the environment. For example, the Bald Mountain mine released 8,000 gallons of cyanide solution in 1993 and 1994. The Battle Mountain mine released 5,000 gallons if cyanide solution in 1995, while the Barrick Goldstrike mine released 2,200 gallons of cyanide solutions in 1996.

The 1985 Report to Congress also noted concern over the environmental effects of acid rock drainage from mining wastes on streams and rivers. The Agency is aware that acid rock drainage problems do exist throughout the United States and do exist in the western part of the US. In 1994 the Agency decided to reevaluate data regarding acid rock drainage (See Acid Rock Drainage Prediction, US EPA, 1994). This report concluded that acid rock drainage was an environmental concern at currently operating mines. The report identified three mines where acid rock drainage had occurred, the Newmont Rain gold mine in Nevada, the Cyprus Thompson Creek mine in Montana, and the LTV iron ore mine in Minnesota. The Newmont Rain mine identified acid rock drainage in a waste rock pile. This drainage was remediated and the company redesigned its waste rock pile to isolate sulfur bearing waste rock. Acid rock drainage was forming in the tailings pond at the Cyprus Thompson Creek mine in Montana. The LTV iron ore mine had acid rock drainage forming in the Dunka pit due to exposure of a sulfur bearing formation not found in any other portion of the mine. That drainage was being collected and treated.

The Agency remains concerned that mines are not routinely required to test waste rock and tailings for acid rock drainage potential throughout the life of a mine. Once acid rock drainage begins, the chemical phenomena continues for extremely long periods of time. Some of the most problematic mine sites on Superfund's National Priorities List (NPL) are sites where acid rock drainage has taken place (Summitville, California Gulch, Clear Creek, Iron Mountain, and Silver Bow/Butte). (See Mine and Mineral Processing Sites on the NPL, EPA, 1997). Acid rock drainage problems have also been identified at non-NPL sites, for example at the Blackbird and Stibnite mines in Idaho (see CERCLA Imminent Hazard - Mining and Mineral Processing Facilities, EPA, 1997).

As previously noted, the Agency has taken emergency action at 72 mine sites. (See CERCLA Imminent Hazard - Mining and Mineral Processing Facilities, EPA, 1997). The Agency cost estimate for removals at 22 of the 72 sites is $208 million, with the unweighted average cost of removal of $9.5 million per site. Agency evaluation of 9 additional non-NPL removal actions shows that the average cost of removal exceeded $800,000 per site. Removal costs at the Blackbird mine were not included in the calculation of average non-NPL removal costs since this action is one of the most expensive (estimated at $24 million) and the data would skew the average. One significant source of contamination at the non-NPL sites was water becoming contaminated through contact with tailings and waste rock.

The Agency has also studied the cost of remediation at mine sites. These costs are

related to cleaning up a wide range of contamination, but these costs are not related to CERCLA actions. The Agency collected clean-up costs at 24 modern (post 1980) operating mines to determine the nature and cost of remediation (See Costs of Remediation at Mine Sites, USEPA, January, 1997). The total cost of remediation at the 24 mines was estimated at $85 million, with the unweighted average per site cost of remediation estimated at $3.5 million. Mines were required to clean up a wide range of environmental problems including the collection and treatment of acid rock drainage, the management of unauthorized discharges to streams, leakage of cyanide solutions, and nitrate contamination of groundwater.

These mounting costs have given rise to a study by EPA's Inspector General, who found critical gaps in some federal and state statutory and regulatory authorities to require adequate financial assurances at hardrock mines. According to the Inspector General, this lack of adequate financial assurances could result in EPA having to assume responsibility for remediation of some hardrock mine sites in the future. The report further finds that EPA had not effectively implemented its existing statutory authorities or used non-regulatory tools, such as partnerships, to minimize the environmental impacts of hardrock mining and help federal and state agencies eliminate financial assurance gaps. (See EPA Inspector General Report: EPA Can Do More to Help Minimize Hardrock Mining Liabilities, 1997).

Natural Resource Damages

Under Section 107(a)(4)(C) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended (CERCLA), persons are liable for damages for injury to, destruction of, or loss of publicly owned or managed natural resources, and the reasonable costs of assessing such injury. The term "natural resources" is defined by CERCLA Section 101(16) to include: land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the United States (including the resources of the fishery conservation zone established by the Fishery Conservation and Management Act of 1976), any State or local government, any foreign government, any Indian tribe, or if such resources are subject to a trust restriction on alienation, any member of an Indian tribe.

Section 301 of CERCLA requires the President to promulgate two types of regulations for the assessment of natural resource damages, Type A regulations, which are the standard procedure for simplified assessments in coastal and marine environments, using the Natural Resource Model for Coastal and Marine Environments (NRDAM/CME), and Type B regulations, which are the general procedures for conducting natural resource damage assessments, and the alternative methodologies for conducting assessments in individual cases. The President delegated the responsibility for issuing these regulations to the Department of Interior (DOI).[5] The DOI has codified its natural resource damage regulations in 43 CFR part 11.

There have been a number of natural resource claims at mine sites. (See Availability of Natural Resource Damage Assessment Modeling, US EPA, December, 1996 and Preliminary

[5] Executive order No. 12316, 46 Fed Reg 42237 (Aug. 14, 1981)

Identification of Approaches Used in Valuating Natural Resources, EPA, 1990). It should be noted that these claims are among the largest in dollar amounts and have long litigation histories. Among the first natural resource claims at mining and mineral processing sites was the claim filed by the State of Idaho against Bunker Hill (see Idaho v. Bunker Hill, 635 F. Supp. 665, 675-676 (D. Idaho 1986). This claim involves natural resource damages to surface water, ground water, and biota at the Bunker Hill Superfund site. The estimated costs of natural resource damage at this site were estimated to exceed $10 million. Natural resource damage claims were recently settled at the Blackbird Mine in Idaho for approximately $60 million. Natural resource claims were filed at the Iron Mountain Superfund site. The estimated costs of natural resource damage at this site are not available, however this site may require perpetual care to treat acid rock drainage.

One of the most extensive natural resource claims at a mine was filed by Montana against the Atlantic Richfield Company at the Clarks Fork Superfund site (see Civil Action No. CV 83-317-HLN-CCL). Based on assessment studies conducted by Montana (see Appendix -Preassessment Screen:Clark Fork River Basin, Montana , October, 1991), the costs of natural resource damages at the Clark Fork have been estimated to exceed $600 million.

In 1992, United States District Court ruled that Utah had failed to adequately assess natural resource damages at the Kennecott Corporation's operations in the Bingham Mining District, near Salt Lake City, Utah. The Court's ruling is important since it directly summarizes the nature and extent of damages at the site. This record indicates that natural resource damages at the site may exceed $200 million dollars.

Currently, the Coeur d'Alene Tribe and the Departments of the Interior and Agriculture are undertaking a Natural Resource Damage Assessment in the Coeur d'Alene Basin of northern Idaho. The study area covers approximately 1500 acres and the main cause of damage is from historic mining and mineral processing. The assessment process began in 1991 and is ongoing. As of 1995, Idaho has settled its portion of the claim for $4 million. A description of the nature and extent of environmental damages in the Coeur d'Alene Basin can be found in the Coeur d'Alene Natural Resource Damage Assessment Public Information Updates dated September 1995, and March 1996. The estimated total costs of natural resource damage at this site were estimated at $600 million to $1.3 billion.

The Government Accounting Office (GAO) issued a report entitled, Superfund-Outlook for and Experience with Natural Resource Damage Settlements, April 1996 (GAO/RCED-96-71), which noted that there are approximately 60 sites on federal lands which may have natural resource damage claims exceeding $5 million. Not all of these sites are mine sites. Of the 98 natural resource damage cases settled as of April, 1995, six of those sites were mine or mineral processing sites with damage costs of $35 million.[6] The GAO testimony indicates that when natural resource damage claims are finalized at mine sites, they are quite costly, involve years of evaluation, and require complicated restoration

[6] Testimony of Peter Guerro, director, Environmental Protection Issues, GAO, for Subcommittee on Water Resources and Environment, House Committee on transportation and Infrastructure Hearing (July 11, 1995).

and recovery approaches.

Population Studies

EPA has collected new population information on both mines and mineral processing sites. EPA expressed beliefs in 1985 Report to Congress and 1986 Regulatory Determination that mining occurred in sparsely populated areas. EPA's new information indicates that there are significant populations within close proximity to hardrock mines and mineral processing sites. (See Population Studies of Mines and Mineral Processing Sites, EPA, 1997) This study analyzed the demographic characteristics of people living near operating mines and mineral processing sites. The Agency utilized data from the 1990 Census of Population. As a preliminary indicator of population, EPA determined the population found within one mile and five miles of 306 operating hardrock mines. EPA believes that there are approximately 1,000 operating hardrock mines in the US. Therefore, the population estimates should be viewed as conservative and the actual total population located near mines is larger than this report indicates.

Agency study of the 306 mines represent mining in the gold, silver, copper, lead/zinc, iron, and phosphate sectors. EPA demographic information indicates that 228,145 persons, 58,996 families, and 89,335 households live within 1 mile of 306 hardrock mines. The study of the distribution of more environmentally sensitive populations around these mines indicates that there are 106,367 children under the age of 19 within one mile, of which 55,374 people are under the age of 4. There are 28,003 people over the age of 65 located within one mile of the mines. The ethnic characteristics of the populations living near mines also warrants attention. There are a total of 51,468 non-white people living within one mile of the mines, of which 9,938 are classified Black, 5,452 are classified Native American, and 33,159 people are classified as Hispanic.

There are 3,465,876 persons, 873,441 families and 1,309,036 households located within 5 miles of those mines. Environmentally sensitive populations located within 5 miles include 1,050,572 children under the age of 19, of which 269,842 are under the age of 4. There are 396,197 people over the age of 65 within 5 miles of the mines. There are a total of 859,738 non-white people living within five miles of the mines, of which 235,274 are classified as Black, 50,714 are classified as Native American, and 500,479 are classified as Hispanic.

EPA is especially concerned about the relatively high percentage of children living within mines and mineral processing sites. Some of these facilities discharge significant quantities of lead, and other pollutants for which children may be especially susceptible. For example there are 63,014 children under the age of 19 located within 5 miles of lead mines, of which 17,172 are under the age of 4.

Agency studied the demographic characteristics of the population located around 112 mineral processing sites. These sites represent those facilities most likely to be affected by the rulemaking. (See Population Studies of Mines and Mineral Processing Sites, EPA, 1997) EPA demographic information indicates that 204,309 persons, 78,373 families, and 107,216 households live within 1 mile of 112 mineral processing sites. The study of the distribution of

more environmentally sensitive populations around these mineral processing sites indicates that there are 135,587 children under the age of 19 within five miles, of which 72,621 people are under the age of 4. There are 28,003 people over the age of 65 located within one mile of the mineral processing sites. There are a total of 51,468 non-white people living within one mile of the mines, of which 51,499 are classified Black, 1,889 are classified Native American, and 45,340 people are classified as Hispanic.

There are 5,623,769 persons, 1,417,579 families and 2,136,729 households located within 5 miles of those mineral processing sites. Environmentally sensitive populations located within 5 miles include 1,585,086 children under the age of 19, of which 419,055 are under the age of 4. There are 727,244 people over the age of 65 within 5 miles of the mineral processing sites. There are a total of 1,342,613 non-white people living within five miles of mineral processing, of which 949,789 are classified as Black, 33,230 are classified as Native American, and 542,471 are classified as Hispanic.

Agency evaluation of the demographic characteristics of population located within one and five miles of mines and mineral processing facilities indicates that large numbers of people are living close to these facilities, and that environmentally sensitive groups within the population (children and the elderly) are also found in large numbers around these sites. This evaluation of population correctly found that mining and mineral processing sites do in fact have the potential to affect large numbers of people living nearby.

Changes in Mining Technology

The technologies used to mine ore have changed significantly since the 1985-1990 Bevill studies. The Agency recognizes that the vast majority of gold mining in the US now relies on the use of cyanide heap and vat/tank leaching. This significant expansion of this form of chemical extraction presents a range of environmental risks was not well understood in 1985. The gold mining sector is now one of the largest industrial consumers of cyanide. The environmental contamination found at the Summitville NPL site clearly shows how a relatively small gold cyanide mine can cause long term environmental damage. The introduction of cyanide heap leach designs which originated in Nevada into dissimilar climates and geologies, also presents different type of risks. For example, the contamination from cyanide process and waste waters from the South Carolina Brewer gold mine was the result of hurricane rainfall. Gold mines are being proposed in settings where cyanide mining has never occurred, and there may not be adequate experience with siting factors to adequately control such issues as snow melt, freeze thaw cycles, and avalanche and seismic threats.

Gold mining using cyanide has been conducted in Nevada for at least twenty years. Over the last five years, a number of gold mines have expanded open pits and will become some of the largest open pit operations in the U.S. This type of mining will require large scale dewatering of the regional aquifer. The Agency does not have adequate information to determine if any long term impacts of dewatering will occur. There is also concern that exposure of minerals in the pit walls may generate acids and mobilize metals which in turn would contaminate water in filling the pits at the conclusion of mining. The Agency also does

not have adequate information to assess if a risk exists.

Phosphate mining and mineral processing in Florida is one of the largest consumers of sulfuric acid. The resultant phosphogypsum wastes not only contains residual phosphoric and sulfuric acids, but it also contains radioactive constituents. These piles and the management of waste acids presents a unique environmental concern given the karst geology of the state. The recent sink holes where millions of gallons of acid and contaminated wastes were discharged to groundwater is of particular concern to EPA.

In-situ mining of copper has been in existence for many years. The pumping of acids into mineral formations si a complex process and a certain amount of fluid is usually lost. The Agency is concerned that it's introduction at sites with complex hydrogeology may threaten surface and groundwater. For example, in-situ mining of copper has been proposed in Michigan at White Pine, located adjacent to Lake Superior.

The Agency is also see mining proposed in environments which are not in remote or arid sites. Gold mining has been proposed in Maine, Oregon, and Washington, there are several copper mines proposed in Michigan and Wisconsin, and large scale cyanide mining is operating or proposed in Alaska. Mining can be conducted in sensitive environments where there is a positive water balance, but care must be taken to address the specific risks these sites pose.

The Agency has also seen a resurgence of new mines in mineral sectors like uranium. There are over a dozen uranium mines currently proposed. Most will utilize in-situ recovery, and many are located on or near tribal lands.

Changes in technologies and mining methods such as in-situ mining, roasting of refractory ores, pressure oxidation, bacteriological leaching, and massive water diversion projects are not well understood by the Agency. The environmental risks associated with these technologies are similarly not well understood and regulatory changes may be warranted.

Changes in Mining Waste Management

The Agency has seen a trend for more mining wastes to be managed in protective impoundments utilizing synthetic liners and in tanks. EPA has conducted a series of studies to determine the feasibility of lining hard rock tailings ponds. In addition, EPA also performed studies comparing the requirements for uranium mill tailings against the management practices of gold cyanide mines and phosphoric acid facilities. Some new uranium mines are complying with the containment standards equivalent to Subtitle C regulations, according to the Nuclear Regulatory Commission (See NRC File). EPA believes that many metal mines and phosphate gypstacks and cooling ponds are comparable in size to uranium mill tailings, yet do not meet Subtitle C standards.

The Agency conducted a series of studies evaluating the design and operation of tailings ponds (See Technical Feasibility of Lining Tailings Ponds, US EPA, January, 1997) This report summarizes Agency study on the design and operation of tailings ponds. Agency evaluation of environmental releases indicate that tailings ponds are a source of surface and ground water contamination. Since the mid-1980's many mining companies have addressed

this risk by designing tailings ponds with liners composed of clay, compacted soils, and synthetic liners. The Agency's 1997 report concludes that there does not appear to be significant engineering reasons why tailings ponds can not be effectively lined with synthetic liners.

The Agency has found that synthetic liners have been routinely installed at hard rock mines since the late 1980's. In 1991, The Western Governors Association prepared a report on gold mining permitting which showed that some gold mines were installing 20-80 mil synthetic liners at tailings ponds (See Abstracts of Selected Precious Metal Mine Permits, Western Governors Association, December, 1991). EPA conducted a series of site visits to operating mines in 1991 and 1992. The purpose of these visits was to gain a better understanding of waste management practices at operating hard rock mines. These visits confirmed that many hard rock mines were installing synthetic liners in 100-400 acre tailings ponds. These reports also noted that in tailings ponds which did not use synthetic liners, most of those units either used compacted soil, clay, or slimed liners. (See Technical Resource Document, Gold and Copper, US EPA, 1994). EPA visited the Stillwater mine in Montana in 1992 since this mine is often referred to regarding the design of its tailings ponds. The Stillwater platinum mine is located in an alpine environment in Montana. The first tailings pond was installed in 1986 and utilized a 100 mil synthetic liner. The company indicated at the time of the visit, that the liner performed well at the site. The Stillwater Mine is currently seeking approval to develop a second tailings ponds which also will be installed with a 100 mil synthetic liner. In 1994, EPA conducted a review of the literature on the design and operation of tailings ponds to determine if there were any engineering constraints to the installation of liners in large waste management units like tailings ponds (See Design and Evaluation of Tailings Dams, US EPA, 1994). This report also concluded that there were no engineering reasons why tailings ponds could not be routinely lined.

The Agency conducted a study to compare the design and operating standards for uranium mill tailings with those established by Florida for phosphogypsum stacks. (See Feasibility Analysis : A Comparison of Phosphogypsum and Uranium Mill Tailing Waste Unit Design, USEPA 1997) . The design standards established under the Uranium Mill Tailings Reclamation Act (40 CFR 192) were designed to protect groundwater from disposal units holding uranium mill tailings. These tailings are similar in size and density to tailings generated in hardrock mining. These standards have also been in place since 1983. During this study the Agency determined that four phosphogypsum stacks (New Wales, Ft. Meade, Plant City, and Nichols) were either built or in the design phase which represented new approaches to managing this type of wastes.

The 1993 Florida Phosphogypsum Management regulations are less stringent than the uranium mill tailings standards defined in 40 CFR 192 Subpart D in several important respects. First, the uranium tailings standards require a double composite liner with two geomembranes and an underlying layer of 3 feet of compacted soil with minimum hydraulic conductivity of 1×10^{-7} cm/sec. The gypsum standards require only one geomembrane and 2 feet of compacted gypsum with minimum hydraulic conductivity of 1×10^{-4} cm/sec (or an underlying 18-inch layer of compacted soil with maximum hydraulic conductivity of 1×10^{-7} cm/sec, which has not been used in any of the four cases analyzed in Section 4). Second, the

uranium tailings standards require a leachate collection system that is also used as detection system. If the measured volume of liquids recovered exceeds a pre-determined action leakage rate, a response action plan is set in motion to mitigate or stop any leaks. In the gypsum case, leakage through the liner is expected and it is actually calculated in the technical reports presented in the permitting process.

All three gypsum stacks constructed or proposed since the enactment of the 1993 Florida Phosphogypsum Management regulations have followed or exceeded the Florida standards but none of the designs approach the protectiveness of the uranium mill tailings standards.

This report shows that phosphogysum stacks can be lined in units with average sizes exceeding 150 acres. Liner design usually involves the use of a 24 inch layer of compacted gypsum followed by a 60 mil geomembrane and the use of concentric underdrains. All of the four lined stacks will have extensive groundwater monitoring systems.

The Agency conducted a study to evaluate current State of Nevada gold cyanide mill tailings facility design, operation, and closure regulations, and compare them to the uranium mill tailings design and operating regulations promulgated at 40 Code of Federal Regulations (CFR) 192. (See Nevada Gold Cyanide Mill Tailings Regulation, US EPA, February, 1997). This report also evaluated the tailings pond designs used at three gold cyanide mill facilities in the State of Nevada. Nevada was selected for the comparison because it is the nation's largest producer of gold, has the largest number of gold cyanide mill facilities, and has promulgated the most advanced cyanide mill tailings facility regulatory framework.

The State of Nevada minimum design criteria for tailings impoundments include a 12 inch thick soil liner with a coefficient of permeability of 10^{-6} cm/sec, or equivalent. The design criteria for tailings impoundments under 192 requires three layers of solution containment - two of flexible geomembrane and a bottom liner of 3 feet of compacted soil with a coefficient of permeability no greater than 10^{-7} cm/sec, with geotextile leak detection collection system between the liners. Nevada regulations require review of dam design, construction and maintenance requirements prior to issuing a dam permit. 40 CFR 192 does not specify requirements for the dam associated with a tailings impoundment. Nevada State regulations are written and enforced to prevent degradation to the waters of the state, where the regulations are written to prevent any release to the groundwater. Because of this difference the Nevada regulations require identification of all drinking water sources, groundwater and surface water sources and quality. Nevada closure requirements are focus on preventing degradation of the waters of the state, and converting the land to a post-mining use. Also due to the low precipitation and high evaporation rates, typically state wide, final covers are designed to hold precipitation for subsequent evaporation. Nevada regulations for post closure monitoring are established on a facility basis, but is no longer than 30 years. The 192 regulations require monitoring of no less than 30 years.

Review of the liner designs at the Newmont Rain, Barrick Bullfrog, and Echo Bay McCoy mines indicate that all were successfully constructed using either 12 inches of amended soil liners or synthetic liners in conjunction with compacted clay liners. It is important to note that while there are differences in regulatory approach between UMTRCA and Nevada, EPA's information indicates that tailings ponds in Nevada are being lined and

that there does not appear to be technological barriers to such installation.

Risk Analysis

The Agency believes that modern risk modeling techniques may provide a more accurate characterization of human health and environmental risks from Bevill-exempt wastes. In the 1985 Report to Congress on Extraction and Beneficiation wastes, the Agency generally characterized environmental damages but did not provide a quantitative estimate releases, exposures, or risks associated with mining waste disposal practices. In the 1990 Report to Congress on Mineral Processing, the Agency similarly characterized environmental damages from mineral processing wastes and went further in providing limited risk modeling by examining contamination through the groundwater pathway.

The Agency's qualitative review of damage cases indicate that the risks posed by disposal of Bevill waste is similar to risks from other industrial hazardous wastes. However, the Agency has not performed any type of quantitative risk modeling using information and data gathered since the initial Bevill studies. Further, the Agency has not modeled or analyzed risks associated other environmental pathways, such as air, soils, surface water, or food chain ingestion. In the case of mining and mineral processing, the air and soils pathways were significant factors in placing several sites on the National Priorities List[7]. However, the release of contaminants through these pathways was not evaluated by the Agency in its decision not to apply more stringent RCRA regulatory controls.

The Agency first identified concern over the health and environmental effects of metallic dusts in the 1985 Report to Congress. In 1991, EPA determined that National Institute for Occupational Safety and Health (NIOSH) had collected dust samples inside mining and mineral processing facilities. This information is summarized in an April, 1991 report form the Agency's consultant (See Summary of NIOSH Bulk Dust Metals Data, from SAIC to S. Hoffman, EPA, April, 1991). NIOSH data provided the Agency with information on the metallic content of dusts found within mining operations, which indicate dusts routinely contain lead, arsenic, chrome, and nickel. This data can not be used to forecast risk since NIOSH did not sample at the site boundary. This data is useful as long as it is used as a surrogate for the types of dusts likely to be found at mining and mineral processing sites.

Agency study of mine sites on the NPL has indicated that metallic dusts have the potential for adversely affecting human health. Recent study of lead bearing dusts at the Tri-State NPL lead site indicated that lead dusts from abandoned lead slag piles were potentially affecting nearby residents. Metal bearing dusts have been identified as a source of contamination at the Bunker Hill NPL site. The Agency for Toxic Substances and Disease Registry (ATSDR) recently completed a Preliminary Public Assessment for Big River Mine Tailings Desloge, 1996. This report concluded that the site located in Missouri is considered a public health hazard due to exposure to windblown lead bearing dusts. (See Memorandum from S. Hoffman to RCRA Docket, Review of Preliminary Public assessment for Big River

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[7] Examples include Atlas Asbestos, Johns-Mansville Asbestos, Anaconda Smelter, Denver Radium, East Helena, Bunker Hill,

Mine Tailings). Of particular interest to the Agency is that while the lead tailings found at the Big River site had been abandoned for many years, they were still threatening public health twenty five years after disposal.

Since the 1985 and 1990 Bevill studies, the Agency has developed much more sophisticated release, fate, and transport modeling methodology. This methodology was recently used to quantify risk for cement kiln dust (CKD), a mineral processing operation similar to many of the operations studied in the 1985 and 1990 Reports to Congress, especially the calcining, elemental phosphorous, and lightweight aggregate mineral sectors. The CKD risk modeling analysis used the MMSOILS model, a screening-level multimedia contaminant release, fate, and transport model, to estimate ambient concentrations of constituents of concern in ground water, air, surface water, soils, and the food chain. MMSOILS was developed by EPA's Office of Research and Development to simulate the release of hazardous constituents from a wide variety of waste management scenarios and their subsequent multimedia transport through key environmental pathways.[8] MMSOILS also simulates numerous cross-media transfers of contaminants (e.g., atmospheric deposition to soil and ground water discharge to streams). As a screening-level model, MMSOILS was designed to provide rough order-of-magnitude exposure estimates in relatively simple environmental settings.

With respect to the groundwater pathway, new advanced risk modeling is similarly available. The risk methodology called the Composite Model for Leachate Migration with Transformation Products (CMTP) is being used by the Agency to predict groundwater exposure in domestic drinking water receptors. The risks posed by some mining and mineral processing wastes, especially those with high levels of lead and arsenic found at many NPL sites, may be more accurately characterized by application of these or other more modern modeling techniques. The Agency solicits comments on the efficacy of applying these types of modeling methodologies to mining and mineral processing wastes.

It should be noted that the Agency conducted a variation of multi-pathway risk analysis of mining to determine if the mining sector should be added to the Toxic Release Inventory (TRI) (See 61 FR 33588, June 27, 1996). The docket for this proposed rule includes evaluations where the Agency conducted risk screening using the Permit Compliance System, the Biennial Report System, the Aerometric Information Retrieval System, and the Facility Index system to assess the likely pollutant loadings caused by mining. Based on this analysis, the Agency proposed to add the mining sector to the TRI.

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[8] U.S. Environmental Protection Agency, Office of Research and Development, MMSOILS: Multimedia Contaminant Fate, Transport, and Exposure Model, Documentation and User's Manual, September 1992 (updated in April 1993).

UNITED STATES
SECURITIES AND EXCHANGE COMMISSION
Washington, D.C. 20549

FORM 8-K

CURRENT REPORT
Pursuant to Section 13 or 15(d) of the
Securities Exchange Act of 1934
Date of Report (Date of earliest event reported): February 22, 2023

THE MOSAIC COMPANY
(Exact name of registrant as specified in its charter)

Delaware	**001-32327**	**20-1026454**
(State or other jurisdiction of incorporation)	(Commission File Number)	(IRS Employer Identification No.)

101 East Kennedy Blvd. **Suite 2500** **Tampa, Florida**	**33602**
(Address of principal executive offices)	(Zip Code)

Registrant's telephone number, including area code: (800) 918-8270

Not applicable
(Former Name or Former Address, if Changed Since Last Report)

Check the appropriate box below if the Form 8-K filing is intended to simultaneously satisfy the filing obligation of the registrant under any of the following provisions (see General Instruction A.2. below):

☐ Written communications pursuant to Rule 425 under the Securities Act (17 CFR 230.425)
☐ Soliciting material pursuant to Rule 14a-12 under the Exchange Act (17 CFR 240.14a-12)
☐ Pre-commencement communications pursuant to Rule 14d-2(b) under the Exchange Act (17 CFR 240.14d-2(b))
☐ Pre-commencement communications pursuant to Rule 13e-4(c) under the Exchange Act (17 CFR 240.13e-4(c))

Securities registered pursuant to Section 12(b) of the Act

Title of each class	Trading Symbol(s)	Name of each exchange on which registered
Common Stock, par value $0.01 per share	MOS	New York Stock Exchange

Indicate by check mark whether the registrant is an emerging growth company as defined in Rule 405 of the Securities Act of 1933 or Rule 12b-2 of the Securities Exchange Act of 1934.

☐ Emerging growth company

If an emerging growth company, indicate by check mark if the registrant has elected not to use the extended transition period for complying with any new or revised financial accounting standards provided pursuant to Section 13(a) of the Exchange Act. ☐

Item 2.02. Results of Operations and Financial Condition.

The following information is being "furnished" in accordance with General Instruction B.2. of Form 8-K and shall not be deemed "filed" for purposes of Section 18 of the Securities Exchange Act of 1934, as amended (the "Exchange Act"), or otherwise subject to the liabilities of that section, nor shall it be deemed to be incorporated by reference in any filing under the Securities Act of 1933, as amended (the "Securities Act"), or the Exchange Act, except as expressly set forth by specific reference in such filing:

Furnished herewith as Exhibit 99.1 and incorporated by reference herein is the text of The Mosaic Company's ("Mosaic," and Mosaic and its subsidiaries, individually or in any combination, "we," "us" or "our") announcement regarding its earnings and results of operations for the quarter and full year ended December 31, 2022, as presented in a press release issued on February 22, 2023.

Furnished herewith as Exhibit 99.2 and incorporated by reference herein is certain performance data for the period ended December 31, 2022 to be published on Mosaic's website.

Item 9.01. Financial Statements and Exhibits.

(d) Exhibits.

Reference is made to the Exhibit Index hereto with respect to the exhibits furnished herewith. The following exhibits are being "furnished" in accordance with General Instruction B.2. of Form 8-K and shall not be deemed "filed" for purposes of Section 18 of the Exchange Act, or otherwise subject to the liabilities of that section, nor shall they be deemed to be incorporated by reference in any filing under the Securities Act or the Exchange Act, except as expressly set forth by specific reference in such filing.

Exhibit No.	Description
99.1	Press release, dated February 22, 2023, of The Mosaic Company regarding its earnings and results of operations for the quarter and full year ended December 31, 2022
99.2	Performance data for the period ended December 31, 2022

SIGNATURES

Pursuant to the requirements of the Securities Exchange Act of 1934, the registrant has duly caused this report to be signed on its behalf by the undersigned hereunto duly authorized.

THE MOSAIC COMPANY

Date: February 22, 2023

By: /s/ Philip E. Bauer
Name: Philip E. Bauer
Title: Senior Vice President, General Counsel and Corporate Secretary

` **Exhibit 99.1**

The Mosaic Company
101 E. Kennedy Blvd., Suite 2500
Tampa, FL 33602
www.mosaicco.com

For Immediate Release

Investors
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THE MOSAIC COMPANY REPORTS FOURTH QUARTER AND FULL YEAR 2022 RESULTS

- ***Full year net income of $3.6 billion, adjusted EBITDA(1) of $6.2 billion***
- ***Cash from operations of $3.9 billion, free cash flow(1) of $2.6 billion***
- ***Retired $550 million of long-term debt and returned $1.9 billion to shareholders through share repurchases and dividends in 2022***
- ***Accelerated share repurchase of $300 million and special dividend of $0.25 per share in the first quarter of 2023***

TAMPA, FL, February 22, 2023 - The Mosaic Company (NYSE: MOS) today reported net income of $3.6 billion and diluted earnings per share (EPS) of $10.06 for full year 2022. Adjusted EBITDA[1] for the year was $6.2 billion and adjusted diluted EPS[1] was $11.01.

The company also reported fourth quarter net income of $523 million and diluted EPS of $1.52. Adjusted EBITDA[1] totaled $1.05 billion for the quarter and adjusted diluted EPS[1] was $1.74.

"Mosaic delivered record results in 2022, and we expect favorable agricultural markets to continue in 2023," said Joc O'Rourke, President and CEO. "Despite significant volatility through the year, our business was able to deliver strong free cash flow and return significant capital to shareholders, while also reinvesting in the business. Mosaic is well positioned to continue delivering strong results in 2023, thanks to our low cost potash operations, our portfolio of value-added phosphate products, and our leading footprint in Brazil, the world's fastest-growing major agricultural market."

Highlights:

- Full year revenues were up 55 percent year-over-year to $19.1 billion, as stronger pricing more than offset lower volumes. The gross margin rate in 2022 was 30 percent, up from 26 percent in 2021.
- Net Income in 2022 totaled $3.6 billion, up 120 percent from 2021. Adjusted EBITDA[1] in 2022 totaled $6.2 billion, up 73 percent from 2021. Cash from operating activities totaled $3.9 billion and Free Cash Flow[1] totaled $2.6 billion.
- Potash operating earnings were $2.8 billion in 2022, up from $837 million in the prior year. Adjusted EBITDA[1] totaled $3.1 billion in 2022, up from $1.3 billion last year. Esterhazy's K3 mine reached its targeted initial annual run-rate of 5.5 million tonnes in the first half of 2022, and output was expanded further with the addition of an eleventh miner, which entered service in the fourth quarter. The decision to stop production at the Colonsay mine in the fourth quarter because of market conditions is expected to be temporary, and a restart is expected in the first half of 2023.

*Free cash flow is defined as cash from operations minus total capital expenditures and adjusted for working capital financing.

[1]See "Non-GAAP Financial Measures" for additional information and reconciliation.

- Phosphate operating earnings were $1.3 billion in 2022, compared to $1.2 billion in 2021. Adjusted EBITDA[1] totaled $2.2 billion in 2022, up from $1.7 billion the prior year. The segment benefited from higher prices more than offsetting lower production and sales volumes, which were impacted by Hurricane Ian, unplanned operational outages, and a slower-than-expected recovery in demand in the second half of the year. Production returned to normal operating rates in February of 2023. MicroEssentials sales volumes totaled 2.8 million tonnes in 2022, with gross margins averaging $33 per tonne higher than commodity fertilizer sales. Performance products now account for 43% of total phosphate segment volumes.

- Mosaic Fertilizantes operating earnings were $910 million in 2022, up from $745 million in 2021. Adjusted EBITDA[1] totaled $1.0 billion in 2022, up from $821 million last year. Mosaic Fertilizantes saw market share for its distribution business grow to approximately 18% in 2022, from 16% in the prior year, and is now Brazil's largest distributor of fertilizer. When combined with direct sales from the production business, total sales volumes accounted for 23% of all fertilizer sales in Brazil.

2023 Capital Allocation Strategy

Mosaic remains committed to a disciplined capital allocation strategy.

- Mosaic anticipates returning virtually all of 2023 generated free cash flow to shareholders through a combination of regular common dividends, special dividends, and share repurchases[2].

- Mosaic expects to initiate an accelerated share repurchase (ASR) of $300 million in first quarter of 2023. Following execution of the ASR, Mosaic will have repurchased shares worth more than $2.5 billion since the third quarter of 2021. As of February 17, shares outstanding totaled 336.5 million shares.

- Mosaic has a regular common dividend target of $0.80 per share[2].

- In an effort to further reward long-term shareholders, Mosaic's Board of Directors has approved a special dividend of $0.25 per share to be distributed on March 30, 2023, to shareholders of record on March 15, 2023.

- Consistent with the maintenance of a balance sheet reflective of investment grade metrics, Mosaic retired $550 million of long-term debt in November 2022 and met its previously established goal of reducing long-term debt by $1 billion.

- Management of assets remains a key focus. Mosaic divested Streamsong Resort in January of 2023 for gross proceeds of $160 million.

- Mosaic will continue to evaluate its capital expenditure budget in 2023. Capex is expected to total $1.3-1.4 billion, with a portion of the spend being directed to projects that we expect will improve operational performance in the phosphates segment. Mosaic is also pursuing high-returning projects. Examples include an expansion of MicroEssentials capacity at our Riverview facility, construction of the new Palmeirante blending and distribution facility in Brazil, construction of a purified phosphoric acid test plant in North America, and extending production from the Taquari potash mine in Brazil. On average, these projects are expected to generate an after tax, internal rate of return of approximately 50%.

[1]See “Non-GAAP Financial Measures” for additional information and reconciliation.

[2]The declarations and payment of future dividends remain at the discretion of the Board of Directors and will be determined based on several factors, including the Company's financial performance and available cash resources.

Segment Analysis

Potash	Q4 2022	Q4 2021	2022	2021
Sales Volumes - million tonnes*	1.9	2.1	8.1	8.2
MOP Selling Price(3)	$581	$414	$632	$285
Gross Margin (GAAP) per tonne	$289	$224	$351	$129
Adjusted Gross Margin (non-GAAP) per tonne(1)	$289	$224	$351	$134
Operating Earnings - millions	$497	$443	$2,768	$837
Segment Adjusted EBITDA(1) - millions	$597	$517	$3,117	$1,286

*Tonnes = finished product tonnes
(3)Average per tonne MOP selling price (fob mine)

The Potash segment reported net sales of $5.2 billion in 2022, up from $2.6 billion in 2021, reflecting the benefit of higher prices. MOP cash costs of production, excluding brine management costs, averaged $78 per tonne, up from $67 in 2021, primarily driven by higher price-related royalties, natural gas prices, other inflationary pressures, and market-related shutdowns during the year. Gross margin per tonne was $351, up from $129 last year, and adjusted gross margin per tonne(1) rose year over year from $134 to $351.

At Esterhazy, 11 miners are now in operation, a twelfth miner is currently being commissioned, and the final thirteenth miner is expected to enter service in the second half of 2023. Upon completion, these three additional miners will add one million tonnes of annual capacity. At Colonsay, production was temporarily halted in December but is expected to restart in the first half of 2023.

Sales volumes in the first quarter are expected to be 1.8-2.0 million tonnes with realized mine-gate MOP prices in the range of $425-$475 per tonne.

Phosphate	Q4 2022	Q4 2021	2022	2021
Sales Volumes - million tonnes*	1.6	1.8	6.6	7.7
DAP Selling Price(4)	$722	$676	$804	$564
Gross Margin (GAAP) per tonne	$148	$254	$268	$170
Adjusted Gross Margin (non-GAAP) per tonne(1)	$167	$259	$274	$173
Operating Earnings (Loss) - millions	$145	$418	$1,347	$1,180
Segment Adjusted EBITDA(1) - millions	$348	$571	$2,219	$1,729

*Tonnes = finished product tonnes
(4)Average DAP Selling Price (fob plant)

Net sales in the Phosphate segment increased to $6.2 billion in 2022, up from $4.9 billion in 2021. Sales volumes decreased from 7.7 million tonnes in 2021 to 6.6 million tonnes, reflecting the impact of Hurricane Ian as well as other unplanned operational outages. This decrease was more than offset by the rise in average realized selling prices to $913 per tonne, up from $618 in 2021. Gross margin per tonne was $268 in 2022, compared to $170 in 2021, and adjusted gross margin per tonne(1) increased to $274 in 2022 from $173 in the prior year.

Mosaic continues to benefit from access to internally produced and attractively priced external ammonia. Realized ammonia costs in 2022 averaged $603 per tonne, compared with the market average of $1,167 per tonne in 2022, and we expect similar benefits in 2023.

Sales volumes in the first quarter are expected to be 1.7-1.9 million tonnes with DAP prices on an FOB basis averaging $625-$675 per tonne. Stripping margins are expected to be in line with the fourth quarter as lower raw material costs offset the decline in realized prices.

(1)See “Non-GAAP Financial Measures” for additional information and reconciliation.

Mosaic Fertilizantes	Q4 2022	Q4 2021	2022	2021
Sales Volumes - million tonnes*	2.5	2.3	9.4	10.1
Finished Product Selling Price	$773	$654	$878	$504
Gross Margin (GAAP) per tonne	$11	$95	$111	$83
Adjusted Gross Margin per tonne[(1)]	$12	$85	$111	$81
Operating Earnings - millions	$(20)	$195	$910	$745
Segment Adjusted EBITDA[(1)] - millions	$29	$197	$1,049	$821

*Tonnes = finished product tonnes

Mosaic Fertilizantes reported net sales of $8.3 billion in 2022, up from $5.1 billion in the prior year, reflecting higher prices, offset by lower volumes. These factors led to significant improvements in gross margin per tonne, which averaged $111 in 2022, up from $83 in 2021, and offset the impact of inflationary cost pressures. Despite lower volumes, Mosaic Fertilizantes saw market share for its distribution business grow from 16% to approximately 18% during the year.

Other

Full-year selling, general and administrative expenses were $498.0 million in 2022 versus $430.5 million in 2021, primarily driven by additional spend related to our Global Digital Acceleration effort.

Mosaic recognized strong earnings from equity investments of $196.0 million, reflecting contribution from the company's share of the MWSPC joint venture in Saudi Arabia. Mosaic received a $25 million dividend distribution from MWSPC in February 2023.

The reported effective tax rate for 2022 was 26.4 percent, and 25.8 percent excluding discrete items. Discrete items included true-up of estimates primarily related to our U.S. tax return and restricted stock units vested during the year above the grant price. The effective rate, excluding discrete items, was driven by the mix of earnings across jurisdictions, tax costs related to repatriation of earnings to the U.S. and benefits related to non-U.S. tax incentives. Cash taxes paid in 2022 were $1.1 billion.

In 2022, net cash provided by operating activities was $3.9 billion and capital expenditures were $1.2 billion.

2023 Market Outlook

Strong agricultural commodity pricing trends are expected to drive a recovery in demand for fertilizers in 2023. Global demand for grain and oilseeds remain high while stock-to-use ratios are at the lowest point in more than 25 years. Food security concerns, rising biofuel consumption, and crop production headwinds suggest elevated crop prices will persist through 2023 and likely beyond. As a result, strong global fertilizer demand is expected in 2023 as growers seek to maximize yields.

Grower profitability has improved significantly as input costs have eased while ag commodity prices have held at elevated levels, and farmer economics in most global growing regions are constructive. Channel inventories for phosphates and potash in North America, Brazil, India, and other key growing regions have been drawn down, but nutrient price volatility has delayed replenishment of these channels. As grower demand ramps up ahead of the Northern Hemisphere's spring planting season, wholesalers and retailers are expected to return to the market to meet farmer demand.

Global phosphate supply remains constrained. China's domestic phosphate industry is undergoing significant change as production is diverted from export markets toward domestic industrial and agricultural uses, a secular trend that is expected to continue.

In potash, price weakness persisted through the winter as a result of aggressive marketing of small volumes from producers in Russia and Belarus seeking to recover market share lost in 2022. However, global supplies remain constrained and are unlikely to be sufficient to allow a return to trend demand and could struggle to satisfy the pent up demand expected in 2023.

[(1)]See "Non-GAAP Financial Measures" for additional information and reconciliation.

2023 Modeling Assumptions

The Company provides the following modeling assumptions for the full year 2023:

Modeling Assumptions	Full Year 2023
Total Capital Expenditures	$1.3 - 1.4 billion
Depreciation, Depletion & Amortization	$830 - $850 million
Selling, General, and Administrative Expense	$475 - $500 million
Net Interest Expense	$170 - $180 million
Effective tax rate	Mid 20's %
Cash tax rate	Low 20's %

Sensitivities Table Using 2022 Cost Structure

The Company provided the following sensitivities to price and foreign exchange rates to help investors anticipate the potential impact of movements in these factors.

Sensitivity	Full year adj. EBITDA impact[1]	2022 Actual
Average MOP Price / tonne (fob mine)[6]	$10/mt price change = $60 million [5]	$632
Average DAP Price / tonne (fob plant)[6]	$10/mt price change = $90 million	$804
Average BRL / USD	0.10 change, unhedged = $10 million[7]	5.16

[5] Includes impact of Canadian Resource Tax

[6] Approximately 20% of DAP price sensitivity impact is expected to be in the Mosaic Fertilizantes segment.; approximately 5% of the MOP price sensitivity impact is expected to be in the Mosaic Fertilizantes segment.

[7] The company hedged about 50 percent of the annual sensitivity. Over longer periods of time, inflation is expected to offset a portion of currency benefits.

About The Mosaic Company

The Mosaic Company is one of the world's leading producers and marketers of concentrated phosphate and potash crop nutrients. Mosaic is a single-source provider of phosphate and potash fertilizers and feed ingredients for the global agriculture industry. More information on the company is available at www.mosaicco.com.

Mosaic will conduct a conference call on Thursday, February 23, 2023, at 11:00 a.m. Eastern Time to discuss fourth quarter and full year 2022 earnings results. A simultaneous webcast of the conference call may be accessed through Mosaic's website at www.mosaicco.com/investors. This webcast will be available up to one year from the time of the earnings call.

This release contains forward-looking statements within the meaning of the Private Securities Litigation Reform Act of 1995. Such statements may include, but are not limited to, statements about proposed or pending common dividends, special dividends, share repurchases, future transactions or strategic plans and other statements about future financial and operating results. Such statements are based upon the current beliefs and expectations of The Mosaic Company's management and are subject to significant risks and uncertainties. These risks and uncertainties include, but are not limited to: the economic impact and operating impacts of the coronavirus (Covid-19) pandemic, political and economic instability and changes in government policies in Brazil and other countries in which we have operations; the predictability and volatility of, and customer expectations about, agriculture, fertilizer, raw material, energy and transportation markets that are subject to competitive and other pressures and economic and credit market conditions; the level of inventories in the distribution channels for crop nutrients; the effect of future product innovations or development of new technologies on demand for our products; changes in foreign currency and exchange rates; international trade risks and other risks associated with Mosaic's international operations and those of joint ventures in which Mosaic participates, including the performance of the Wa'ad Al Shamal Phosphate Company (also known as

[1]See "Non-GAAP Financial Measures" for additional information and reconciliation.

MWSPC), the future success of current plans for MWSPC and any future changes in those plans; difficulties with realization of the benefits of our natural gas based pricing ammonia supply agreement with CF Industries, Inc., including the risk that the cost savings initially anticipated from the agreement may not be fully realized over its term or that the price of natural gas or ammonia during the term are at levels at which the pricing is disadvantageous to Mosaic; customer defaults; the effects of Mosaic's decisions to exit business operations or locations; changes in government policy; changes in environmental and other governmental regulation, including expansion of the types and extent of water resources regulated under federal law, carbon taxes or other greenhouse gas regulation, implementation of numeric water quality standards for the discharge of nutrients into Florida waterways or efforts to reduce the flow of excess nutrients into the Mississippi River basin, the Gulf of Mexico or elsewhere; further developments in judicial or administrative proceedings, or complaints that Mosaic's operations are adversely impacting nearby farms, business operations or properties; difficulties or delays in receiving, increased costs of or challenges to necessary governmental permits or approvals or increased financial assurance requirements; resolution of global tax audit activity; the effectiveness of Mosaic's processes for managing its strategic priorities; adverse weather conditions affecting operations in Central Florida, the Mississippi River basin, the Gulf Coast of the United States, Canada or Brazil, and including potential hurricanes, excess heat, cold, snow, rainfall or drought; actual costs of various items differing from management's current estimates, including, among others, asset retirement, environmental remediation, reclamation or other environmental regulation, Canadian resources taxes and royalties, or the costs of the MWSPC; reduction of Mosaic's available cash and liquidity, and increased leverage, due to its use of cash and/or available debt capacity to fund financial assurance requirements and strategic investments; brine inflows at Mosaic's potash mines; other accidents and disruptions involving Mosaic's operations, including potential mine fires, floods, explosions, seismic events, sinkholes or releases of hazardous or volatile chemicals; and risks associated with cyber security, including reputational loss; as well as other risks and uncertainties reported from time to time in The Mosaic Company's reports filed with the Securities and Exchange Commission. Actual results may differ from those set forth in the forward-looking statements. The declarations and payment of future dividends and special dividends remain at the discretion of the Board of Directors.

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Non-GAAP Financial Measures

This press release includes the presentation and discussion of non-GAAP diluted net earnings per share guidance, or adjusted EPS, non-GAAP gross margin per tonne, or adjusted gross margin per tonne, non-GAAP adjusted EBITDA, and free cash flow, referred to as non-GAAP financial measures. Generally, a non-GAAP financial measure is a supplemental numerical measure of a company's performance, financial position or cash flows that either excludes or includes amounts that are not normally excluded or included in the most directly comparable measure calculated and presented in accordance with U.S. generally accepted accounting principles, or GAAP. Non-GAAP financial measures should not be considered as substitutes for, or superior to, measures of financial performance prepared in accordance with GAAP. In addition, because non-GAAP measures are not determined in accordance with GAAP, they are thus susceptible to varying interpretations and calculations and may not be comparable to other similarly titled measures of other companies. Adjusted metrics, including adjusted EPS, adjusted gross margin, and adjusted EBITDA are calculated by excluding the impact of notable items from the GAAP measure. Notable items impact on gross margin and EBITDA is pretax. Notable items impact on diluted net earnings per share is calculated as the notable item amount plus income tax effect, based on expected annual effective tax rate, divided by diluted weighted average shares. Management believes that these adjusted measures provide securities analysts, investors, management and others with useful supplemental information regarding our performance by excluding certain items that may not be indicative of, or are unrelated to, our core operating results. Free Cash Flow is defined as net cash provided by operating activities less capital expenditures and adjusted for changes in working capital financing. Management utilizes these adjusted measures in analyzing and assessing Mosaic's overall performance and financial trends, for financial and operating decision-making, and to forecast and plan for future periods. These adjusted measures also assist our management in comparing our and our competitors' operating results. We are not providing forward looking guidance for U.S. GAAP reported diluted net earnings per share, gross margin per tonne, or a quantitative reconciliation of forward-looking adjusted EPS, adjusted gross margin and adjusted EBITDA because we are unable to predict with reasonable certainty our notable items without unreasonable effort. Historically, our notable items have included, but are not limited to, foreign currency transaction gain or loss, unrealized gain or loss on derivatives, acquisition-related fees, discrete tax items, contingencies and certain other gains or losses. These items are uncertain, depend on various factors, and could have a material impact on U.S. GAAP reported results for the guidance period. Reconciliations for Non-GAAP financial measures contained in this press release are found below. Reconciliations for current and historical periods beginning with the quarter ended March 31, 2021 for consolidated adjusted EPS and adjusted EBITDA, as well as segment adjusted EBITDA and adjusted gross margin per tonne are provided in the Selected Calendar Quarter Financial Information performance data for the related periods. This information is being furnished under Exhibit 99.2 of the Form 8-K and available on our website at www.mosaicco.com in the "Financial Information - Quarterly Earnings" section under the "Investors" tab.

(1)See "Non-GAAP Financial Measures" for additional information and reconciliation.

For the three months ended December 31, 2022, the Company reported the following notable items which, combined, negatively impacted earnings per share by $0.22:

Description	Segment	Line item	Amount (in millions)	Tax effect (in millions)	EPS impact (per share)
Foreign currency transaction gain (loss)	Consolidated	Foreign currency transaction gain (loss)	$ 75	$ (18)	$ 0.16
Unrealized gain (loss) on derivatives	Corporate and Other	Cost of goods sold	$ 14	$ (4)	$ 0.03
Closed and indefinitely idled facility costs	Phosphate	Other operating income (expense)	(11)	3	(0.03)
FX functional currency	Mosaic Fertilizantes	Cost of goods sold	(1)	—	—
Fixed asset write-off	Phosphate	Other operating income (expense)	(6)	2	(0.01)
ARO Adjustment	Potash	Other operating income (expense)	3	(1)	0.01
Discrete tax items	Consolidated	(Provision for) benefit from income taxes	—	(9)	(0.03)
Realized gain (loss) on RCRA Trust Securities	Phosphates	Other non-operating income (expense)	(20)	5	(0.04)
Environmental reserve	Phosphates	Other operating income (expense)	(44)	11	(0.09)
Hurricane Ian idle costs	Phosphates	Cost of goods sold	(30)	8	(0.07)
Insurance proceeds	Phosphates	Other operating income (expense)	5	(1)	0.01
Pension plan termination settlement	Consolidated	Other non-operating income (expense)	(42)	10	(0.09)
Environmental reserve	Potash	Other operating income (expense)	(28)	7	(0.06)
Lease termination and severance	Corporate and Other	Other operating income (expense)	(4)	1	(0.01)
Total Notable Items			$ (89)	$ 14	$ (0.22)

For the three months ended December 31, 2021, the Company reported the following notable items which, combined, negatively impacted earnings per share by $0.19:

Description	Segment	Line item	Amount (in millions)	Tax effect (in millions)	EPS impact (per share)
Foreign currency transaction gain (loss)	Consolidated	Foreign currency transaction gain (loss)	$ (44)	$ 11	$ (0.09)
Unrealized gain (loss) on derivatives	Corporate and Other	Cost of goods sold	(18)	5	(0.03)
Closed and indefinitely idled facility costs	Phosphates	Other operating income (expense)	(9)	3	(0.02)
Pre-acquisition reserve adjustment	Mosaic Fertilizantes	Other operating income (expense)	5	(2)	0.01
Realized gain on RCRA Trust Securities	Phosphates	Other non-operating income (expense)	(2)	1	—
Discrete tax items	Consolidated	(Provision for) benefit from income taxes	—	(26)	(0.06)
ARO Adjustment	Phosphates	Other operating income (expense)	(5)	1	(0.01)
FX functional currency	Mosaic Fertilizantes	Cost of goods sold	23	(6)	0.04
Hurricane Ida recovery	Phosphates	Cost of goods sold/Other income (expense)	(9)	2	(0.02)
ARO Adjustment	Potash	Other operating income (expense)	(4)	1	(0.01)
Total Notable Items			$ (63)	$ (10)	$ (0.19)

Condensed Consolidated Statements of Earnings
(in millions, except per share amounts)

The Mosaic Company **(unaudited)**

	Three months ended December 31,		Years ended December 31,	
	2022	2021	2022	2021
Net sales	$ 4,481.3	$ 3,841.0	$ 19,125.2	$ 12,357.4
Cost of goods sold	3,512.9	2,692.4	13,369.4	9,157.1
Gross margin	968.4	1,148.6	5,755.8	3,200.3
Selling, general and administrative expenses	132.9	123.5	498.0	430.5
Impairment, restructuring and other expenses	—	—	—	158.1
Other operating expenses	134.9	55.4	472.5	143.2
Operating earnings	700.6	969.7	4,785.3	2,468.5
Interest expense, net	(33.8)	(39.0)	(137.8)	(169.1)
Foreign currency transaction gain (loss)	75.1	(43.7)	97.5	(78.5)
Other (expense) income	(64.7)	(1.1)	(102.5)	3.9
Earnings from consolidated companies before income taxes	677.2	885.9	4,642.5	2,224.8
Provision for (benefit from) income taxes	206.0	245.5	1,224.3	597.7
Earnings from consolidated companies	471.2	640.4	3,418.2	1,627.1
Equity in net earnings (loss) of nonconsolidated companies	57.3	21.0	196.0	7.8
Net earnings including noncontrolling interests	528.5	661.4	3,614.2	1,634.9
Less: Net earnings (loss) attributable to noncontrolling interests	5.3	(3.4)	31.4	4.3
Net earnings attributable to Mosaic	$ 523.2	$ 664.8	$ 3,582.8	$ 1,630.6
Diluted net earnings per share attributable to Mosaic	$ 1.52	$ 1.76	$ 10.06	$ 4.27
Diluted weighted average number of shares outstanding	343.8	377.5	356.0	381.6

Condensed Consolidated Balance Sheets
(in millions, except per share amounts)

The Mosaic Company **(unaudited)**

	December 31, 2022	December 31, 2021
Assets		
Current assets:		
Cash and cash equivalents	$ 735.4	$ 769.5
Receivables, net	1,699.9	1,531.9
Inventories	3,543.1	2,741.4
Other current assets	578.2	282.5
Total current assets	6,556.6	5,325.3
Property, plant and equipment, net	12,678.7	12,475.3
Investments in nonconsolidated companies	885.9	691.8
Goodwill	1,116.3	1,172.2
Deferred income taxes	752.3	997.1
Other assets	1,396.2	1,374.7
Total assets	$ 23,386.0	$ 22,036.4
Liabilities and Equity		
Current liabilities:		
Short-term debt	$ 224.9	$ 302.8
Current maturities of long-term debt	985.3	596.6
Structured accounts payable arrangements	751.2	743.7
Accounts payable	1,292.5	1,260.7
Accrued liabilities	2,279.9	1,883.6
Total current liabilities	5,533.8	4,787.4
Long-term debt, less current maturities	2,411.9	3,382.2
Deferred income taxes	1,010.1	1,016.2
Other noncurrent liabilities	2,236.0	2,102.1
Equity:		
Preferred stock, $0.01 par value, 15,000,000 shares authorized, none issued and outstanding as of December 31, 2022 and 2021	—	—
Common stock, $0.01 par value, 1,000,000,000 shares authorized, 391,964,464 shares issued and 339,071,423 shares outstanding as of December 31, 2022, 390,815,099 shares issued and 368,732,231 shares outstanding as of December 31, 2021	3.4	3.7
Capital in excess of par value	—	478.0
Retained earnings	14,203.4	12,014.2
Accumulated other comprehensive loss	(2,152.2)	(1,891.8)
Total Mosaic stockholders' equity	12,054.6	10,604.1
Non-controlling interests	139.6	144.4
Total equity	12,194.2	10,748.5
Total liabilities and equity	$ 23,386.0	$ 22,036.4

Condensed Consolidated Statements of Cash Flows
(in millions, except per share amounts)

The Mosaic Company **(unaudited)**

	Three months ended December 31, 2022	Three months ended December 31, 2021	Years ended December 31, 2022	Years ended December 31, 2021
Cash Flows from Operating Activities:				
Net cash provided by operating activities	$ 955.7	$ 430.4	$ 3,935.8	$ 2,187.0
Cash Flows from Investing Activities:				
Capital expenditures	(340.5)	(362.8)	(1,247.3)	(1,288.6)
Purchases of available-for-sale securities - restricted	(302.9)	(110.3)	(762.5)	(433.6)
Proceeds from sale of available-for-sale securities - restricted	298.4	106.9	743.0	410.1
Other	1.9	(25.5)	7.2	(10.2)
Net cash used in investing activities	(343.1)	(391.7)	(1,259.6)	(1,322.3)
Cash Flows from Financing Activities:				
Payments of short-term debt	(1,602.6)	(701.6)	(1,761.2)	(726.6)
Proceeds from issuance of short-term debt	1,827.7	701.6	1,980.5	726.6
Payments from inventory financing arrangement	(200.5)	—	(1,651.5)	—
Proceeds from inventory financing arrangement	—	302.7	1,348.8	302.7
Payments of structured accounts payable arrangements	(332.5)	(352.7)	(1,476.6)	(1,028.4)
Proceeds from structured accounts payable arrangements	439.9	360.0	1,460.5	1,122.7
Payments of long-term debt	(565.8)	(13.6)	(610.3)	(608.3)
Collections of transferred receivables	1,068.5	134.7	2,352.1	445.0
Payments of transferred receivables	(1,069.7)	(101.1)	(2,433.2)	(363.9)
Repurchases of stock	(64.0)	(390.9)	(1,665.2)	(410.9)
Cash dividends paid	(51.1)	(27.8)	(197.7)	(103.7)
Dividends paid to non-controlling interest	(21.3)	(11.8)	(38.0)	(31.3)
Other	(1.6)	(2.9)	13.1	(6.0)
Net cash used in financing activities	(573.0)	(103.4)	(2,678.7)	(682.1)
Effect of exchange rate changes on cash	(8.0)	(7.7)	(29.7)	9.3
Net change in cash, cash equivalents and restricted cash	31.6	(72.4)	(32.2)	191.9
Cash, cash equivalents and restricted cash—beginning of year	722.5	858.7	786.3	594.4
Cash, cash equivalents and restricted cash—end of year	$ 754.1	$ 786.3	$ 754.1	$ 786.3

	Years ended December 31, 2022	Years ended December 31, 2021
Reconciliation of cash, cash equivalents and restricted cash reported within the consolidated balance sheets to the consolidated statements of cash flows:		
Cash and cash equivalents	$ 735.4	$ 769.5
Restricted cash in other current assets	8.2	8.3
Restricted cash in other assets	10.5	8.5
Total cash, cash equivalents and restricted cash shown in the statement of cash flows	$ 754.1	$ 786.3

Reconciliation of Non-GAAP Financial Measures

Earnings Per Share Calculation

	Three months ended December 31,		Years ended December 31,	
	2022	2021	2022	2021
Net earnings attributed to Mosaic	$ 523.2	$ 664.8	$ 3,582.8	$ 1,630.6
Basic weighted average number of shares outstanding	340.3	379.1	352.4	378.1
Dilutive impact of share-based awards	3.5	3.2	3.6	3.5
Diluted weighted average number of shares outstanding	343.8	382.3	356.0	381.6
Basic net earnings per share	$ 1.54	$ 1.75	$ 10.17	$ 4.31
Diluted net earnings per share	$ 1.52	$ 1.74	$ 10.06	$ 4.27
Notable items impact on earnings per share	$ 0.22	$ 0.19	$ 0.95	$ 0.77
Adjusted earnings per share	$ 1.74	$ 1.93	$ 11.01	$ 5.04

Free Cash Flow

	Years ended December 31,
	2022
Net cash provided by operating activities	$ 3,936
Capital expenditures	(1,247)
Working capital financing[(a)]	(95)
Free cash flow	$ 2,594

[(a)] Includes net proceeds (payments) from inventory financing arrangements, structured accounts payable arrangements and commercial paper borrowings.

Reconciliation of Non-GAAP Financial Measures

Consolidated Earnings *(in millions)*	Year ended December 31, 2022
Consolidated net earnings attributable to Mosaic	$ 3,583
Less: Consolidated interest expense, net	(139)
Plus: Consolidated depreciation, depletion and amortization	933
Plus: Accretion expense	81
Plus: Share-based compensation expense	27
Plus: Consolidated provision for income taxes	1,224
Less: Equity in net earnings of nonconsolidated companies, net of dividends	196
Plus: Notable items not included above	425
Adjusted EBITDA	$ 6,216

Potash Earnings *(in millions)*	Three months ended December 31, 2022	Three months ended December 31, 2021	Years ended December 31, 2022	Years ended December 31, 2021
Operating Earnings	$ 497	$ 443	$ 2,768	$ 837
Plus: Depreciation, Depletion and Amortization	73	68	307	268
Plus: Accretion Expense	2	2	8	10
Plus: Foreign Exchange Gain (Loss)	6	3	(19)	8
Plus: Other Non Operating Income	—	—	—	—
Plus: Notable Items	19	1	53	163
Adjusted EBITDA	$ 597	$ 517	$ 3,117	$ 1,286

Phosphate Earnings *(in millions)*	Three months ended December 31, 2022	Three months ended December 31, 2021	Years ended December 31, 2022	Years ended December 31, 2021
Operating Earnings	$ 145	$ 418	$ 1,347	$ 1,180
Plus: Depreciation, Depletion and Amortization	111	115	485	429
Plus: Accretion Expense	15	13	55	48
Plus: Foreign Exchange Gain (Loss)	(4)	(11)	(8)	9
Plus: Other Non Operating Income (Expense)	(9)	—	(32)	8
Less: Earnings (Loss) from Consolidated Noncontrolling Interests	5	(3)	32	6
Plus: Notable Items	95	33	404	61
Adjusted EBITDA	$ 348	$ 571	$ 2,219	$ 1,729

Mosaic Fertilizantes *(in millions)*	Three months ended December 31, 2022	Three months ended December 31, 2021	Years ended December 31, 2022	Years ended December 31, 2021
Operating Earnings	$ (20)	$ 195	$ 910	$ 745
Plus: Depreciation, Depletion and Amortization	45	28	125	101
Plus: Accretion Expense	5	4	17	14
Plus: Foreign Exchange Gain (Loss)	38	(31)	8	(70)
Plus: Other Non Operating Income (Expense)	(1)	(1)	(4)	(6)
Less: Earnings (Loss) from Consolidated Noncontrolling Interests	—	—	(1)	(1)
Plus: Notable Items	(38)	2	(8)	36
Adjusted EBITDA	$ 29	$ 197	$ 1,049	$ 821

Reconciliation of Non-GAAP Financial Measures

Potash Earnings *(in millions)*	Three months ended December 31, 2022	Three months ended December 31, 2021	Years ended December 31, 2022	Years ended December 31, 2021
Gross Margin / tonne	$ 289	$ 224	$ 351	$ 129
Notable items in gross margin	—	—	—	5
Adjusted gross margin / tonne	$ 289	$ 224	$ 351	$ 134

Phosphates Earnings *(in millions)*	Three months ended December 31, 2022	Three months ended December 31, 2021	Years ended December 31, 2022	Years ended December 31, 2021
Gross Margin / tonne	$ 148	$ 254	$ 268	$ 170
Notable items in gross margin	19	5	6	3
Adjusted gross margin / tonne	$ 167	$ 259	$ 274	$ 173

Mosaic Fertilizantes Earnings *(in millions)*	Three months ended December 31, 2022	Three months ended December 31, 2021	Years ended December 31, 2022	Years ended December 31, 2021
Gross Margin / tonne	$ 11	$ 95	$ 111	$ 83
Notable items in gross margin	1	(10)	—	(2)
Adjusted gross margin / tonne	$ 12	$ 85	$ 111	$ 81

Exhibit 99.2

The Mosaic Company
Selected Calendar Quarter Financial Information
(Unaudited)

	Q1 2021	Q2 2021	Q3 2021	Q4 2021	Q1 2022	Q2 2022	Q3 2022	Q4 2022
Consolidated data *(in millions, except per share)*								
Diluted net earnings (loss) per share	**$ 0.41**	**$ 1.14**	**$ 0.97**	**$ 1.76**	**$ 3.19**	**$ 2.85**	**$ 2.42**	**$ 1.52**
Notable items impact on earnings per share[a]	(0.16)	(0.03)	(0.38)	(0.19)	0.78	(0.79)	(0.80)	(0.22)
Adjusted diluted net earnings per share[a]	$ 0.57	$ 1.17	$ 1.35	$ 1.95	$ 2.41	$ 3.64	$ 3.22	$ 1.74
Diluted weighted average # of shares outstanding	382.8	383.3	383.2	377.5	370.1	363.1	347.7	343.8
Total Net Sales	**$ 2,297**	**$ 2,801**	**$ 3,419**	**$ 3,841**	**$ 3,922**	**$ 5,373**	**$ 5,348**	**$ 4,481**
Cost of goods sold	1,862	2,049	2,554	2,693	2,483	3,526	3,846	3,512
Gross Margin	**$ 435**	**$ 752**	**$ 865**	**$ 1,148**	**$ 1,439**	**$ 1,847**	**$ 1,502**	**$ 969**
SG&A	102	108	98	123	133	108	124	133
Other operating (income) expense[p]	20	160	65	55	50	65	224	136
Operating earnings	**$ 313**	**$ 484**	**$ 702**	**$ 970**	**$ 1,256**	**$ 1,674**	**$ 1,154**	**$ 700**
Interest expense, net	(45)	(37)	(48)	(39)	(40)	(34)	(31)	(34)
Consolidated foreign currency gain/(loss)	(46)	111	(100)	(44)	311	(227)	(61)	75
Earnings from consolidated companies before income taxes	**225**	**559**	**554**	**886**	**1,527**	**1,377**	**1,061**	**677**
Provision for (benefit from) income taxes	60	116	177	245	372	369	277	206
Earnings (loss) from consolidated companies	**$ 165**	**$ 443**	**$ 377**	**$ 641**	**$ 1,155**	**$ 1,008**	**$ 784**	**$ 471**
Equity in net earnings (loss) of nonconsolidated companies	(7)	(4)	(1)	20	31	36	72	57
Less: Net earnings (loss) attributable to noncontrolling interests	1	2	4	(4)	4	8	14	5
Net earnings (loss) attributable to Mosaic	**$ 157**	**$ 437**	**$ 372**	**$ 665**	**$ 1,182**	**$ 1,036**	**$ 842**	**$ 523**
After tax Notable items included in earnings	$ (63)	$ (10)	$ (145)	$ (73)	$ 288	$ (286)	$ (277)	$ (75)
Gross Margin Rate	*19 %*	*27 %*	*25 %*	*30 %*	*37 %*	*34 %*	*28 %*	*22 %*
Effective Tax Rate (including discrete tax)	*27 %*	*21 %*	*32 %*	*28 %*	*24 %*	*27 %*	*26 %*	*30 %*
Discrete Tax benefit (expense)	$ (4)	$ 49	$ (19)	$ (26)	$ 9	$ (14)	$ (12)	$ (9)
Depreciation, Depletion and Amortization	$ 209	$ 204	$ 186	$ 214	$ 226	$ 245	$ 229	$ 233
Accretion Expense	$ 17	$ 19	$ 18	$ 19	$ 20	$ 20	$ 19	$ 22
Share-Based Compensation Expense	$ 15	$ 4	$ 5	$ 6	$ 16	$ (1)	$ 6	$ 6
Notable Items	$ 50	$ 8	$ 163	$ 59	$ (374)	$ 361	$ 354	$ 84
Adjusted EBITDA[b]	**$ 560**	**$ 829**	**$ 969**	**$ 1,227**	**$ 1,451**	**$ 2,028**	**$ 1,686**	**$ 1,051**
Net cash provided by (used in) operating activities	$ 319	$ 1,015	$ 423	$ 431	$ 506	$ 1,585	$ 889	$ 956
Cash paid for interest (net of amount capitalized)	1	88	18	82	4	80	3	83
Cash paid for income taxes (net of refunds)	83	36	54	36	259	233	253	370
Net cash used in investing activities	$ (309)	$ (271)	$ (351)	$ (392)	$ (297)	$ (265)	$ (355)	$ (343)
Capital expenditures	(289)	(297)	(340)	(363)	(291)	(263)	(354)	(341)
Net cash (used in) provided by financing activities	$ 122	$ (82)	$ (618)	$ (107)	$ (125)	$ (1,331)	$ (650)	$ (573)
Cash dividends paid	(19)	(29)	(28)	(28)	(41)	(54)	(51)	(51)
Effect of exchange rate changes on cash	$ (20)	$ 69	$ (32)	$ (5)	$ 31	$ (33)	$ (20)	$ (8)
Net change in cash and cash equivalents	**$ 112**	**$ 731**	**$ (579)**	**$ (72)**	**$ 115**	**$ (44)**	**$ (135)**	**$ 32**
Short-term debt	$ 15	$ —	$ —	$ 303	$ 481	$ 17	$ 201	$ 225
Long-term debt (including current portion)	4,470	4,463	3,995	3,979	3,977	3,960	3,959	3,397
Cash & cash equivalents	692	1,418	843	770	882	839	703	735
Net debt	**$ 3,793**	**$ 3,045**	**$ 3,152**	**$ 3,512**	**$ 3,576**	**$ 3,138**	**$ 3,457**	**$ 2,887**
Segment Contributions *(in millions)*								
Phosphates	$ 1,001	$ 1,175	$ 1,281	$ 1,466	$ 1,496	$ 1,801	$ 1,577	$ 1,310
Potash	477	663	589	897	1,060	1,580	1,432	1,136
Mosaic Fertilizantes	764	1,036	1,755	1,535	1,488	2,260	2,629	1,910
Corporate and Other[c]	55	(73)	(206)	(57)	(122)	(268)	(290)	125
Total net sales	**$ 2,297**	**$ 2,801**	**$ 3,419**	**$ 3,841**	**$ 3,922**	**$ 5,373**	**$ 5,348**	**$ 4,481**
Phosphates	$ 153	$ 283	$ 326	$ 418	$ 493	$ 578	$ 131	$ 145
Potash	125	49	220	443	563	915	793	497
Mosaic Fertilizantes	90	170	290	195	187	420	323	(20)
Corporate and Other[c]	(55)	(18)	(134)	(86)	13	(239)	(93)	78
Consolidated operating earnings (loss)	**$ 313**	**$ 484**	**$ 702**	**$ 970**	**$ 1,256**	**$ 1,674**	**$ 1,154**	**$ 700**

Phosphates[d]	2,062	1,982	1,836	1,813	1,661	1,675	1,651	1,571
Potash[d]	1,980	2,326	1,808	2,072	1,792	2,304	2,142	1,863
Mosaic Fertilizantes	2,064	2,341	3,350	2,347	1,822	2,320	2,824	2,472
Corporate and Other	475	427	292	432	370	533	221	466
Total finished product tonnes sold *('000 tonnes)*	**6,581**	**7,076**	**7,286**	**6,664**	**5,645**	**6,832**	**6,838**	**6,372**
Sales of Performance Products (third party) ('000 tonnes) [e]	1,023	917	1,132	1,077	711	741	790	1,265

The Mosaic Company - Phosphates Segment
Selected Calendar Quarter Financial Information
(Unaudited)

	Q1 2021	Q2 2021	Q3 2021	Q4 2021	Q1 2022	Q2 2022	Q3 2022	Q4 2022
Net Sales and Gross Margin *(in millions, except per tonne)*								
Segment income statement								
Net Sales	**$ 1,001**	**$ 1,175**	**$ 1,281**	**$ 1,466**	**$ 1,496**	**$ 1,801**	**$ 1,577**	**$ 1,310**
Cost of Goods Sold	828	866	917	1,006	968	1,159	1,219	1,078
Gross Margin	**$ 173**	**$ 309**	**$ 364**	**$ 460**	**$ 528**	**$ 642**	**$ 358**	**$ 232**
Notable Items Included in Gross Margin	—	—	(17)	(9)	—	—	(9)	(30)
Adjusted Gross Margin[b]	**$ 173**	**$ 309**	**$ 381**	**$ 469**	**$ 528**	**$ 642**	**$ 367**	**$ 262**
SG&A	10	10	7	15	8	10	8	15
Other operating (income) expense	10	16	31	27	27	54	219	72
Operating Earnings	**$ 153**	**$ 283**	**$ 326**	**$ 418**	**$ 493**	**$ 578**	**$ 131**	**$ 145**
Plus: Depreciation, Depletion and Amortization	102	106	106	115	120	133	121	111
Plus: Accretion Expense	12	10	13	13	13	14	13	15
Plus: Foreign Exchange Gain (Loss)	6	8	6	(11)	(7)	—	3	(4)
Plus: Other Non operating Income (Expense)	5	2	1	—	—	(24)	1	(9)
Less: Earnings (loss) from Consolidated Noncontrolling Interests	3	2	4	(3)	4	9	14	5
Plus: Notables Items	(4)	1	31	33	17	66	226	95
Adjusted EBITDA[b]	**$ 271**	**$ 408**	**$ 479**	**$ 571**	**$ 632**	**$ 758**	**$ 481**	**$ 348**
Capital expenditures	$ 153	$ 150	$ 161	$ 187	$ 148	$ 157	$ 168	$ 159
Gross Margin $ / tonne of finished product	$ 84	$ 156	$ 198	$ 254	$ 318	$ 383	$ 217	$ 148
Adjusted Gross Margin $ / tonne of finished product	$ 84	$ 156	$ 208	$ 259	$ 318	$ 383	$ 222	$ 167
Gross margin as a percent of sales	*17 %*	*26 %*	*28 %*	*31 %*	*35 %*	*36 %*	*23 %*	*18 %*
Freight included in finished goods (in millions)	$ 97	$ 103	$ 96	$ 103	$ 90	$ 94	$ 98	$ 95
Idle/Turnaround costs (excluding notable items)	$ 41	$ 38	$ 33	$ 25	$ 31	$ 79	$ 79	$ 70
Operating Data								
Sales volumes *('000 tonnes)[d]*								
DAP/MAP	1,210	880	907	907	917	814	824	844
Performance products[f]	724	971	812	813	659	780	750	640
Other products[i]	128	131	117	93	85	81	77	87
Total Finished Product[d]	**2,062**	**1,982**	**1,836**	**1,813**	**1,661**	**1,675**	**1,651**	**1,571**
DAP selling price (fob plant)[r]	$ 426	$ 544	$ 605	$ 676	$ 785	$ 920	$ 809	$ 722
Average finished product selling price (destination)[g]	$ 477	$ 580	$ 681	$ 758	$ 877	$ 1,048	$ 924	$ 794
Production Volumes *('000 tonnes)*								
Total tonnes produced[h]	1,911	1,827	1,738	1,857	1,745	1,636	1,664	1,602
Operating Rate	*77 %*	*73 %*	*70 %*	*75 %*	*70 %*	*66 %*	*67 %*	*65 %*
Raw Materials								
Ammonia used in production (tonnes)	281	256	255	287	258	236	236	243
% manufactured ammonia used in production	*23 %*	*29 %*	*20 %*	*20 %*	*34 %*	*22 %*	*5 %*	*42 %*
Sulfur used in production	841	824	792	848	818	764	781	745
% prilled sulfur used in production	*27 %*	*18 %*	*21 %*	*17 %*	*11 %*	*5 %*	*— %*	*3 %*
Realized costs *($/tonne)*								
Ammonia (tonne)[j]	$ 316	$ 382	$ 424	$ 463	$ 532	$ 591	$ 665	$ 653
Sulfur (long ton)[k]	$ 119	$ 172	$ 214	$ 229	$ 281	$ 385	$ 436	$ 348
Blended rock	$ 61	$ 60	$ 59	$ 64	$ 61	$ 64	$ 68	$ 78
Phosphates cash conversion costs / production tonne[s]	$ 63	$ 68	$ 68	$ 71	$ 76	$ 86	$ 85	$ 96
Cash costs of U.S. mined rock / production tonne[t]	$ 36	$ 37	$ 41	$ 44	$ 50	$ 46	$ 41	$ 48
ARO cash spending (in millions)	$ 32	$ 33	$ 26	$ 26	$ 33	$ 28	$ 33	$ 43

MWSPC equity earnings (loss)	$ (8)	$ (7)	$ (1)	$ 20	$ 31	$ 34	$ 72	$ 58
MWSPC total sales tonnes (DAP/MAP/NPK)	612	360	486	653	592	413	599	684
Miski Mayo external sales revenue	$ 7	$ 7	$ 15	$ 14	$ 17	$ 18	$ 21	$ 38

The Mosaic Company - Potash Segment
Selected Calendar Quarter Financial Information
(Unaudited)

	Q1 2021	Q2 2021	Q3 2021	Q4 2021	Q1 2022	Q2 2022	Q3 2022	Q4 2022
Net Sales and Gross Margin *(in millions, except per tonne)*								
Segment income statement								
Net Sales	**$ 477**	**$ 663**	**$ 589**	**$ 897**	**$ 1,060**	**$ 1,580**	**$ 1,432**	**$ 1,136**
Cost of Goods Sold	337	446	353	433	481	652	633	598
Gross Margin	**$ 140**	**$ 217**	**$ 236**	**$ 464**	**$ 579**	**$ 928**	**$ 799**	**$ 538**
Notable Items Included in Gross Margin	(22)	(15)	—	—	—	—	—	—
Adjusted Gross Margin[b]	**$ 162**	**$ 232**	**$ 236**	**$ 464**	**$ 579**	**$ 928**	**$ 799**	**$ 538**
SG&A	7	8	8	11	7	8	6	9
Other operating (income) expense [p]	8	160	8	10	9	5	—	32
Operating Earnings	**$ 125**	**$ 49**	**$ 220**	**$ 443**	**$ 563**	**$ 915**	**$ 793**	**$ 497**
Plus: Depreciation, Depletion and Amortization	80	70	50	68	77	81	76	73
Plus: Accretion Expense	2	4	2	2	2	2	2	2
Plus: Foreign Exchange Gain (Loss)	15	28	(38)	3	17	(23)	(19)	6
Plus: Other Non operating Income (Expense)	—	—	—	—	—	—	—	—
Plus: Notable Items	(10)	134	38	1	(8)	23	19	19
Adjusted EBITDA[b]	**$ 212**	**$ 285**	**$ 272**	**$ 517**	**$ 651**	**$ 998**	**$ 871**	**$ 597**
Capital expenditures	$ 97	$ 98	$ 123	$ 92	$ 65	$ 67	$ 78	$ 72
Gross Margin $ / tonne of finished product	$ 71	$ 93	$ 131	$ 224	$ 323	$ 403	$ 373	$ 289
Adjusted Gross Margin $ / tonne of finished product	$ 82	$ 100	$ 131	$ 224	$ 323	$ 403	$ 373	$ 289
Gross margin as a percent of sales	*29 %*	*33 %*	*40 %*	*52 %*	*55 %*	*59 %*	*56 %*	*47 %*
Supplemental Cost Information								
Canadian resource taxes	$ 35	$ 54	$ 57	$ 113	$ 157	$ 274	$ 258	$ 238
Royalties	$ 9	$ 10	$ 8	$ 15	$ 27	$ 32	$ 31	$ 24
Freight[l]	$ 78	$ 99	$ 60	$ 65	$ 70	$ 76	$ 55	$ 66
Idle/Turnaround costs (excluding notable items)	$ 2	$ 13	$ 36	$ 11	$ 15	$ 9	$ 13	$ 24
Operating Data								
Sales volumes *('000 tonnes)*[d]								
MOP	1,747	2,064	1,547	1,870	1,532	2,045	1,952	1,707
Performance products[m]	221	252	202	187	243	245	178	143
Other products[i]	12	10	59	15	17	14	12	13
Total Finished Product[d]	**1,980**	**2,326**	**1,808**	**2,072**	**1,792**	**2,304**	**2,142**	**1,863**
Crop Nutrients North America	876	1,117	642	610	618	727	439	594
Crop Nutrients International	967	1,061	1,067	1,301	1,020	1,415	1,574	1,145
Non-Agricultural	137	148	99	161	154	162	129	125
Total Finished Product[d]	**1,980**	**2,326**	**1,808**	**2,072**	**1,792**	**2,304**	**2,142**	**1,863**
MOP selling price (fob mine)[o]	$ 200	$ 243	$ 290	$ 414	$ 582	$ 678	$ 666	$ 581
Average finished product selling price (destination)[g]	$ 241	$ 285	$ 326	$ 433	$ 591	$ 686	$ 669	$ 610
Production Volumes *('000 tonnes)*								
Production Volume	2,285	2,131	1,580	2,208	2,200	2,436	2,266	2,151
Operating Rate	*94 %*	*88 %*	*65 %*	*81 %*	*80 %*	*87 %*	*81 %*	*77 %*
MOP cash costs of production excluding brine / production tonne[n]	$ 64	$ 62	$ 72	$ 71	$ 81	$ 78	$ 78	$ 76
ARO cash spending *(in millions)*	$ 1	$ 3	$ 7	$ 15	$ 18	$ 13	$ 11	$ 5

Average CAD / USD	$ 1.266	$ 1.229	$ 1.259	$ 1.261	$ 1.267	$ 1.276	$ 1.304	$ 1.358

The Mosaic Company - Mosaic Fertilizantes Segment
Selected Calendar Quarter Financial Information
(Unaudited)

	Q1 2021	Q2 2021	Q3 2021	Q4 2021	Q1 2022	Q2 2022	Q3 2022	Q4 2022
Net Sales and Gross Margin *(in millions, except per tonne)*								
Segment income statement								
Net Sales	**$ 764**	**$ 1,036**	**$ 1,755**	**$ 1,535**	**$ 1,488**	**$ 2,260**	**$ 2,629**	**$ 1,910**
Cost of Goods Sold	661	852	1,423	1,313	1,269	1,810	2,281	1,882
Gross Margin	**$ 103**	**$ 184**	**$ 332**	**$ 222**	**$ 219**	**$ 450**	**$ 348**	**$ 28**
Notable Items Included in Gross Margin	—	(6)	3	23	(18)	—	14	(1)
Adjusted Gross Margin[b]	**$ 103**	**$ 190**	**$ 329**	**$ 199**	**$ 237**	**$ 450**	**$ 334**	**$ 29**
SG&A	18	18	20	24	21	27	25	29
Other operating (income) expense	(5)	(4)	22	3	11	3	—	19
Operating Earnings	**$ 90**	**$ 170**	**$ 290**	**$ 195**	**$ 187**	**$ 420**	**$ 323**	**$ (20)**
Plus: Depreciation, Depletion and Amortization	23	24	26	28	25	27	28	45
Plus: Accretion Expense	3	4	3	4	4	4	4	5
Plus: Foreign Exchange Gain (Loss)	(33)	34	(40)	(31)	119	(83)	(66)	38
Plus: Other Non operating Income (Expense)	(1)	(2)	(2)	(1)	(1)	(1)	(1)	(1)
Less: Earnings from Consolidated Noncontrolling Interests	—	(1)	—	—	—	(1)	—	—
Plus: Notable Items	22	(28)	40	2	(101)	76	55	(38)
Adjusted EBITDA[b]	**$ 104**	**$ 203**	**$ 317**	**$ 197**	**$ 233**	**$ 444**	**$ 343**	**$ 29**
Capital expenditures	$ 39	$ 44	$ 52	$ 81	$ 75	$ 39	$ 92	$ 100
Gross Margin $ / tonne of finished product	$ 50	$ 78	$ 99	$ 95	$ 120	$ 194	$ 123	$ 11
Adjusted Gross Margin $ / tonne of finished product	$ 50	$ 81	$ 98	$ 85	$ 130	$ 194	$ 118	$ 12
Gross margin as a percent of sales	*13 %*	*18 %*	*19 %*	*14 %*	*15 %*	*20 %*	*13 %*	*1 %*
Idle/Turnaround costs (excluding notable items)	$ 5	$ 9	$ 16	$ 25	$ 9	$ 30	$ 44	$ 29
Operating Data								
Sales volumes *('000 tonnes)*								
Phosphate produced in Brazil	536	686	722	599	737	638	488	505
Potash produced in Brazil	63	66	56	59	46	46	33	40
Purchased nutrients for distribution[q]	1,465	1,589	2,572	1,689	1,039	1,636	2,303	1,927
Total Finished Product	**2,064**	**2,341**	**3,350**	**2,347**	**1,822**	**2,320**	**2,824**	**2,472**
Sales of Performance Products ('000 tonnes)[e]	$ 176	$ 299	$ 584	$ 375	$ 155	$ 290	$ 574	$ 473
Brazil MAP price (Brazil production delivered price to third party)	$ 421	$ 589	$ 622	$ 765	$ 882	$ 1,021	$ 866	$ 663
Average finished product selling price (destination)[g]	$ 370	$ 442	$ 524	$ 654	$ 817	$ 974	$ 931	$ 773
Production Volumes *('000 tonnes)*								
MAP	235	218	210	233	261	266	174	261
TSP	107	127	130	102	131	129	85	82
SSP	301	287	350	349	312	275	343	332
DCP	106	117	130	124	127	85	114	126
NPK	54	52	65	55	64	55	25	49
Total phosphate tonnes produced	**803**	**801**	**885**	**863**	**895**	**810**	**741**	**851**
MOP	82	92	97	97	94	38	69	100
Phosphate operating rate	*82 %*	*82 %*	*91 %*	*89 %*	*92 %*	*83 %*	*76 %*	*87 %*
Potash operating rate	*63 %*	*71 %*	*75 %*	*74 %*	*72 %*	*29 %*	*55 %*	*80 %*
Realized Costs ($/tonne)								
Ammonia/tonne[j]	$ 381	$ 527	$ 640	$ 775	$ 1,145	$ 1,396	$ 1,267	$ 1,354

Sulfur (long ton)[k]	$ 124	$ 177	$ 222	$ 251	$ 337	$ 384	$ 432	$ 402
Blended rock	$ 73	$ 80	$ 81	$ 83	$ 105	$ 102	$ 106	$ 106
Purchases *('000 tonnes)*								
DAP/MAP from Mosaic	64	96	62	89	102	102	30	38
MicroEssentials® from Mosaic	203	418	344	243	248	448	370	205
Potash from Mosaic/Canpotex	489	473	1,023	550	398	663	798	417
Phosphate cash conversion costs in BRL, Production / tonne[s]	R$334	R$359	R$347	R$388	R$403	R$506	R$533	R$483
Potash cash conversion costs in BRL, production / tonne	R$879	R$1,076	R$986	R$1,059	R$1,296	R$2,285	R$1,591	R$1,176
Mined rock costs in BRL, cash produced / tonne	R$392	R$409	R$430	R$456	R$557	R$500	R$525	R$632
ARO cash spending (in millions)	$ 5	$ 5	$ 5	$ 5	$ 2	$ 4	$ 5	$ 11
Average BRL / USD	$ 5.470	$ 5.301	$ 5.225	$ 5.579	$ 5.235	$ 4.917	$ 5.244	$ 5.255

The Mosaic Company - Corporate and Other Segment
Selected Calendar Quarter Financial Information
(Unaudited)

	Q1 2021	Q2 2021	Q3 2021	Q4 2021	Q1 2022	Q2 2022	Q3 2022	Q4 2022
Net Sales and Gross Margin *(in millions)*								
Segment income statement								
Net Sales	**$ 55**	**$ (73)**	**$ (206)**	**$ (57)**	**$ (122)**	**$ (268)**	**$ (290)**	**$ 125**
Cost of Goods Sold	36	(115)	(139)	(59)	(235)	(95)	(287)	(46)
Gross Margin (Loss)	**$ 19**	**$ 42**	**$ (67)**	**$ 2**	**$ 113**	**$ (173)**	**$ (3)**	**$ 171**
Notable items Included in Gross Margin	(8)	38	(26)	(18)	100	(62)	(76)	14
Adjusted Gross Margin (Loss)[(b)]	**$ 27**	**$ 4**	**$ (41)**	**$ 20**	**$ 13**	**$ (111)**	**$ 73**	**$ 157**
SG&A	67	72	63	73	97	63	85	80
Other operating (income) expense	7	(12)	4	15	3	3	5	13
Operating Earnings (Loss)	**$ (55)**	**$ (18)**	**$ (134)**	**$ (86)**	**$ 13**	**$ (239)**	**$ (93)**	**$ 78**
Plus: Depreciation, Depletion and Amortization	4	4	4	3	4	4	4	4
Plus: Share-Based Compensation Expense	15	4	5	6	16	(1)	6	6
Plus: Foreign Exchange Gain (Loss)	(34)	41	(28)	(4)	182	(121)	21	34
Plus: Other Non operating Income (Expense)	—	1	—	—	2	(11)	(1)	(53)
Less: Earnings (Loss) from Consolidated Noncontrolling Interests	(1)	—	—	—	—	—	—	—
Plus: Notable Items	42	(99)	54	23	(282)	196	54	8
Adjusted EBITDA[(b)]	**$ (27)**	**$ (67)**	**$ (99)**	**$ (58)**	**$ (65)**	**$ (172)**	**$ (9)**	**$ 77**
Elimination of profit in inventory income (loss) included in COGS	$ (3)	$ (39)	$ (60)	$ (29)	$ (76)	$ (180)	$ 104	$ 171
Unrealized gain (loss) on derivatives included in COGS	$ (8)	$ 38	$ (26)	$ (17)	$ 100	$ (59)	$ (76)	$ 14
Operating Data								
Sales volumes *('000 tonnes)*	475	427	292	432	370	533	221	466
Sales of Performance Products ('000 tonnes)	29	28	13	12	1	14	9	6
Average finished product selling price (destination)[(g)]	$ 336	$ 421	$ 466	$ 539	$ 597	$ 732	$ 720	$ 692
Purchases *('000 tonnes)*								
DAP/MAP from Mosaic	—	—	—	—	—	—	6	47
MicroEssentials® from Mosaic	—	5	1	4	15	—	15	1
Potash from Mosaic/Canpotex	400	163	218	304	220	471	332	337

The Mosaic Company
Selected Calendar Quarter Financial Information
(Unaudited)

Notable Items

Q4 2022

Description	Segment	Line Item	Amount (in millions)	Tax Effect(u) (in millions)	EPS Impact (per basic share)
Foreign currency transaction gain (loss)	Consolidated	Foreign currency transaction gain (loss)	$ 75	$ (18)	$ 0.16
Unrealized gain (loss) on derivatives	Corporate and Other	Cost of goods sold	14	(4)	0.03
Closed and indefinitely idled facility costs	Phosphate	Other operating income (expense)	(11)	3	(0.03)
FX functional currency	Mosaic Fertilizantes	Cost of goods sold	(1)	—	—
Fixed asset write-off	Phosphate	Other operating income (expense)	(6)	2	(0.01)
ARO Adjustment	Potash	Other operating income (expense)	3	(1)	0.01
Discrete tax items	Consolidated	(Provision for) benefit from income taxes	—	(9)	(0.03)
Realized gain (loss) on RCRA Trust Securities	Phosphates	Other non-operating income (expense)	(20)	5	(0.04)
Environmental reserve	Phosphates	Other operating income (expense)	(44)	11	(0.09)
Hurricane Ian idle costs	Phosphates	Cost of goods sold	(30)	8	(0.07)
Insurance proceeds	Phosphates	Other operating income (expense)	5	(1)	0.01
Pension plan termination settlement	Consolidated	Other non-operating income (expense)	(42)	10	(0.09)
Environmental reserve	Potash	Other operating income (expense)	(28)	7	(0.06)
Lease termination and severance	Corporate and Other	Other operating income (expense)	(4)	1	(0.01)
Total Notable Items			**$ (89)**	**$ 14**	**$ (0.22)**

Q3 2022

Description	Segment	Line Item	Amount (in millions)	Tax Effect(u) (in millions)	EPS Impact (per basic share)
Foreign currency transaction gain (loss)	Consolidated	Foreign currency transaction gain (loss)	$ (61)	$ 16	$ (0.13)
Unrealized gain (loss) on derivatives	Corporate and Other	Cost of goods sold	(76)	20	(0.16)
Closed and indefinitely idled facility costs	Phosphate	Other operating income (expense)	(12)	4	(0.02)
FX functional currency	Mosaic Fertilizantes	Cost of goods sold	14	(4)	0.03
Discrete tax items	Consolidated	(Provision for) benefit from income taxes	—	(12)	(0.04)
ARO Adjustment	Phosphates	Other operating income (expense)	(143)	36	(0.31)
Environmental reserve	Phosphates	Other operating income (expense)	(71)	18	(0.15)
Hurricane Ian idle costs	Phosphates	Cost of goods sold	(9)	2	(0.02)
Insurance proceeds	Phosphates	Other operating income (expense)	4	(1)	0.01
ARO Adjustment	Mosaic Fertilizantes	Other operating income (expense)	(3)	1	(0.01)
Total Notable Items			**$ (357)**	**$ 80**	**$ (0.80)**

Q2 2022

Description	Segment	Line Item	Amount (in millions)	Tax Effect(u) (in millions)	EPS Impact (per basic share)
Foreign currency transaction gain (loss)	Consolidated	Foreign currency transaction gain (loss)	$ (227)	$ 57	$ (0.47)
Unrealized gain (loss) on derivatives	Corporate and Other	Cost of goods sold	(59)	15	(0.12)
Closed and indefinitely idled facility costs	Phosphate	Other operating income (expense)	(9)	3	(0.03)
Discrete tax items	Consolidated	(Provision for) benefit from income taxes	—	(14)	(0.04)
Realized gain (loss) on RCRA Trust Securities	Phosphates	Other non-operating income (expense)	(26)	7	(0.05)
Gain on sale of plant	Mosaic Fertilizantes	Other operating income (expense)	7	(2)	0.02
ARO Adjustment	Phosphates	Other operating income (expense)	(5)	1	(0.01)
Environmental reserve	Phosphates	Other operating income (expense)	(30)	7	(0.06)
Write down of investment	Corporate and Other	Other non-operating income (expense)	(12)	3	(0.02)
Inventory lower of cost or market	Corporate and Other	Cost of goods sold	(3)	1	(0.01)
Total Notable Items			**$ (364)**	**$ 78**	**$ (0.79)**

Q1 2022

Description	Segment	Line Item	Amount (in millions)	Tax Effect[(u)] (in millions)	EPS Impact (per basic share)
Foreign currency transaction gain (loss)	Consolidated	Foreign currency transaction gain (loss)	$ 311	$ (78)	$ 0.62
Unrealized gain (loss) on derivatives	Corporate and Other	Cost of goods sold	100	(25)	0.21
Closed and indefinitely idled facility costs	Phosphate	Other operating income (expense)	(9)	3	(0.02)
FX functional currency	Mosaic Fertilizantes	Cost of goods sold	(18)	5	(0.03)
Fixed asset write-off	Phosphate	Other operating income (expense)	(4)	1	(0.01)
ARO Adjustment	Potash	Other operating income (expense)	(9)	2	(0.02)
Discrete tax items	Consolidated	(Provision for) benefit from income taxes	—	9	0.03
Total Notable Items			**$ 371**	**$ (83)**	**$ 0.78**

Q4 2021

Description	Segment	Line Item	Amount (in millions)	Tax Effect[(u)] (in millions)	EPS Impact (per basic share)
Foreign currency transaction gain (loss)	Consolidated	Foreign currency transaction gain (loss)	$ (44)	$ 11	$ (0.09)
Unrealized gain (loss) on derivatives	Corporate and Other	Cost of goods sold	(18)	5	(0.03)
Closed and indefinitely idled facility costs	Phosphates	Other operating income (expense)	(9)	3	(0.02)
Pre-acquisition reserve adjustment	Mosaic Fertilizantes	Other operating income (expense)	5	(2)	0.01
Realized gain on RCRA Trust Securities	Phosphates	Other non-operating income (expense)	(2)	1	—
Discrete tax items	Consolidated	(Provision for) benefit from income taxes	—	(26)	(0.06)
ARO Adjustment	Phosphates	Other operating income (expense)	(5)	1	(0.01)
FX functional currency	Mosaic Fertilizantes	Cost of goods sold	23	(6)	0.04
Hurricane Ida recovery	Phosphates	Cost of goods sold/Other income (expense)	(9)	2	(0.02)
ARO Adjustment	Potash	Other operating income (expense)	(4)	1	(0.01)
Total Notable Items			**$ (63)**	**$ (10)**	**$ (0.19)**

Q3 2021

Description	Segment	Line Item	Amount (in millions)	Tax Effect(u) (in millions)	EPS Impact (per basic share)
Foreign currency transaction gain (loss)	Consolidated	Foreign currency transaction gain (loss)	$ (100)	$ 25	$ (0.19)
Unrealized gain (loss) on derivatives	Corporate and Other	Cost of goods sold	(26)	6	(0.05)
Closed and indefinitely idled facility costs	Phosphates	Other operating income (expense)	(11)	3	(0.03)
Pre-acquisition reserve adjustment	Mosaic Fertilizantes	Other operating income (expense)	(3)	1	(0.01)
Discrete tax items	Consolidated	(Provision for) benefit from income taxes	—	(19)	(0.05)
ARO Adjustment	Phosphates	Other operating income (expense)	(13)	3	(0.03)
FX functional currency	Mosaic Fertilizantes	Cost of goods sold	3	(1)	0.01
Hurricane Ida recovery	Phosphates	Cost of goods sold/Other income (expense)	(18)	5	(0.03)
Total Notable Items			**$ (168)**	**$ 23**	**$ (0.38)**

Q2 2021

Description	Segment	Line Item	Amount (in millions)	Tax Effect(u) (in millions)	EPS Impact (per basic share)
Foreign currency transaction gain (loss)	Consolidated	Foreign currency transaction gain (loss)	$ 111	$ (27)	$ 0.21
Unrealized gain (loss) on derivatives	Corporate and Other	Cost of goods sold	38	(10)	0.08
Closed and indefinitely idled facility costs	Phosphates	Other operating income (expense)	(11)	3	(0.02)
Closed and indefinitely idled facility costs	Potash	Other operating income (expense)	(4)	1	—
Accelerated depreciation	Potash	Cost of goods sold	(15)	4	(0.04)
Realized gain on RCRA Trust Securities	Phosphates	Other non-operating income (expense)	1	—	—
Discrete tax items	Consolidated	(Provision for) benefit from income taxes	—	6	0.01
ARO Adjustment	Phosphates	Other operating income (expense)	(3)	1	—
FX functional currency	Mosaic Fertilizantes	Cost of goods sold	(6)	1	(0.01)
Esterhazy closure costs	Potash	Restructuring	(158)	43	(0.30)
Gain on sale of warehouse	Corporate and Other	Other operating income (expense)	20	(5)	0.04
Total Notable Items			**$ (27)**	**$ 17**	**$ (0.03)**

Q1 2021

Description	Segment	Line Item	Amount (in millions)	Tax Effect(u) (in millions)	EPS Impact (per basic share)
Foreign currency transaction gain (loss)	Consolidated	Foreign currency transaction gain (loss)	$ (46)	$ 10	$ (0.09)
Unrealized gain (loss) on derivatives	Corporate and Other	Cost of goods sold	(8)	2	(0.02)
Closed and indefinitely idled facility costs	Phosphates	Other operating income (expense)	(10)	3	(0.02)
Closed and indefinitely idled facility costs	Potash	Other operating income (expense)	(5)	2	(0.01)
Accelerated depreciation	Potash	Cost of goods sold	(22)	5	(0.04)
Pre-acquisition reserve adjustment	Mosaic Fertilizantes	Other operating income (expense)	11	(3)	0.02
Realized gain on RCRA Trust Securities	Phosphates	Other non-operating income (expense)	3	(1)	0.01
Discrete tax items	Consolidated	(Provision for) benefit from income taxes	—	(4)	(0.01)
Total Notable Items			**$ (77)**	**$ 14**	**$ (0.16)**

Footnotes

(a) Notable items impact on Earnings Per Share is calculated as notable item amount plus income tax effect, based on expected annual effective tax rate, divided by diluted weighted average shares. Adjusted Diluted Net Earnings per Share is defined as diluted net earnings (loss) per share excluding the impact of notable items. See "Non-GAAP Reconciliations".
(b) See definition of Adjusted EBITDA and Adjusted Gross Margin under "Non-GAAP Reconciliations".
(c) Includes elimination of intersegment sales.
(d) Finished product sales volumes include intersegment sales.
(e) Includes MicroEssentials, K-Mag, Aspire and Sus-Terra sales tonnes.
(f) Includes MicroEssentials performance products.
(g) Average price of all finished products sold by Potash, Phosphates, Mosaic Fertilizantes and India/China.
(h) Includes crop nutrient dry concentrates and animal feed ingredients.
(i) Includes finished goods sales of feed and other products.
(j) Amounts are representative of our average ammonia costs in cost of goods sold.
(k) Amounts are representative of our average sulfur costs in cost of goods sold.
(l) Includes inbound freight, outbound freight and warehousing costs on K-Mag, animal feed and domestic MOP sales.
(m) Includes K-Mag and Aspire finished performance products.
(n) MOP cash costs of production are reflective of actual costs during the period excluding brine management costs, depreciation, depletion, accretion, carbon-based and Canadian resource tax, idle and turnaround costs. Total Production costs for MOP production excludes K-Mag costs, Aspire raw material costs and incremental Aspire operating costs.
(o) Excludes industrial and feed sales. Price has been calculated using the average monthly foreign exchange rate.
(p) Includes $158 million related to the closure of the Esterhazy K1 and K2 mine shafts in Q2 2021.
(q) Includes sales volumes of phosphate and potash nutrients purchased from other Mosaic segments and Canpotex.
(r) Includes intersegment sales.
(s) Total production costs less depreciation, ARO costs including accretion and idle and turnaround costs divided by metric tonnes of finished phosphate production in the period.
(t) Total production costs less depreciation, ARO costs including accretion and idle and turnaround costs divided by metric tonnes of rock produced in the period.
(u) Tax impact is based on our expected annual effective tax rate.

The Mosaic Company
Selected Calendar Quarter Financial Information
(Unaudited)

Non-GAAP Financial Measures

In addition to financial measures prepared in accordance with U.S. generally accepted accounting principles ("GAAP"), Mosaic has presented in this Selected Calendar Quarter Financial Information certain non-GAAP financial measures, or measures calculated based on non-GAAP financial measures, including: Adjusted Diluted Net Earnings Per Share, Consolidated Adjusted EBITDA, Segment Adjusted EBITDA, and Adjusted Gross Margin. Generally, a non-GAAP financial measure is a supplemental numerical measure of a company's performance, financial position or cash flows that either excludes or includes amounts that are not normally excluded or included in the most directly comparable measure calculated and presented in accordance with GAAP. Each of the non-GAAP financial measures we present is determined as described below.

The non-GAAP financial measures we present should not be considered as substitutes for, or superior to, measures of financial performance prepared in accordance with GAAP. In addition, because these non-GAAP measures, as presented, are not determined in accordance with GAAP, they are thus susceptible to varying interpretations and calculations and may not be comparable to other similarly titled measures of other companies.

Adjusted Diluted Net Earnings Per Share

Adjusted diluted net earnings per share is defined as diluted net earnings per share, excluding the impact of notable items. Notable items impact on diluted net earnings per share is calculated as notable item amount plus income tax effect, based on expected annual effective tax rate, divided by diluted weighted average shares. Management believes that adjusted diluted net earnings per share provides securities analysts, investors and others, in addition to management, with useful supplemental information regarding our performance by excluding certain items that may not be indicative of or are unrelated to our core operating results. Management utilizes adjusted diluted net earnings per share in analyzing and assessing Mosaic's overall performance, for financial and operating decision-making, and to forecast and plan for the future periods. Adjusted diluted net earnings per share also assists our management in comparing our and our competitors' operating results. Reconciliations of adjusted diluted net earnings per share to diluted net earnings per share for the periods presented are provided under "Consolidated Data" on the first page of this Selected Calendar Quarter Financial Information.

Consolidated Adjusted EBITDA

Consolidated Adjusted EBITDA is defined as consolidated Net Income (Loss) before net interest expense, depreciation, depletion and amortization, asset retirement obligation accretion, share-based compensation expense and provision for/(benefit) from income taxes. Consolidated Adjusted EBITDA is also adjusted for notable items that management excludes in analyzing our performance. Consolidated Adjusted EBITDA is a non-GAAP financial measure that we provide to assist securities analysts, investors, lenders and others in their comparisons of operational performance, valuation and debt capacity across companies with differing capital, tax and legal structures. Consolidated Adjusted EBITDA should not be considered as an alternative to, or more meaningful than, consolidated Net Income (Loss) as a measure of operating performance. A reconciliation of Consolidated Net Income (Loss) to Consolidated Adjusted EBITDA is provided below.

(*in millions*)	Q1 2021	Q2 2021	Q3 2021	Q4 2021	Q1 2022	Q2 2022	Q3 2022	Q4 2022
Consolidated Net Income (Loss)	$ 157	$ 437	$ 372	$ 665	$ 1,182	$ 1,036	$ 842	$ 523
Less: Consolidated Interest Expense, Net	(45)	(37)	(48)	(39)	(40)	(34)	(31)	(34)
Plus: Consolidated Depreciation, Depletion & Amortization	209	204	186	214	226	245	229	233
Plus: Accretion Expense	17	19	17	19	20	20	19	22
Plus: Share-Based Compensation Expense	15	4	5	6	16	(1)	6	6
Plus: Consolidated Provision for (Benefit from) Income Taxes	60	116	177	245	372	369	277	206
Less: Equity in net earnings (loss) of nonconsolidated companies, net of dividends	(7)	(4)	(1)	20	31	36	72	57
Plus: Notable Items not included above	50	8	163	59	(374)	361	354	84
Consolidated Adjusted EBITDA	$ 560	$ 829	$ 969	$ 1,227	$ 1,451	$ 2,028	$ 1,686	$ 1,051

Segment Adjusted EBITDA

Adjusted EBITDA presented at the segment level is defined as the related segment's operating earnings (loss) plus depreciation, depletion and amortization plus asset retirement obligation accretion plus foreign exchange gain (loss) plus other income (expense) plus equity earnings (loss) less equity earnings (loss) from noncontrolling interests. Adjusted EBITDA is also

adjusted for notable items that management excludes in analyzing our performance. We provide these non-GAAP financial measures because we believe they are relevant and useful to securities analysts, investors and others because they are part of our internal management reporting and planning process, and our management uses these measures to evaluate the operational performance and valuation of our segments. Management also uses these measures as a method of comparing segment, performance with that of its competitors. Segment Adjusted EBITDA should not be considered as alternatives to, or more meaningful than, segment Operating Earnings (Loss) and segment Operating Earnings (Loss)/sales tonne, respectively, as measures of operating performance. Management believes Operating Earnings (Loss) and segment Operating Earnings (Loss)/sales tonne, respectively, are the most directly comparable GAAP measures because we do not allocate taxes on a segment basis. Reconciliations of Segment Adjusted EBITDA to segment Operating Earnings (Loss) and segment Operating (Loss) Earnings/sales tonne, respectively, are provided as part of each segment's Selected Calendar Quarter Financial Information.

Adjusted Gross Margin

Adjusted gross margin is defined as gross margin excluding the impact of notable items. Management believes the adjusted measures provides security analysts, investors, management & others with useful supplemental information regarding our performance by excluding certain items that may not be indicative of, or are unrelated to, our core operating results. Management utilizes adjusted gross margin in analyzing and assessing Mosaic's overall performance for financial and operating decision-making and to forecast and plan for future periods.

UNITED STATES
SECURITIES AND EXCHANGE COMMISSION
Washington, D.C. 20549

FORM 8-K

CURRENT REPORT
Pursuant to Section 13 or 15(d) of the
Securities Exchange Act of 1934
Date of Report (Date of earliest event reported): February 21, 2024

THE MOSAIC COMPANY
(Exact name of registrant as specified in its charter)

Delaware	001-32327	20-1026454
(State or other jurisdiction of incorporation)	(Commission File Number)	(IRS Employer Identification No.)

101 East Kennedy Blvd. Suite 2500 Tampa, Florida	33602
(Address of principal executive offices)	(Zip Code)

Registrant's telephone number, including area code: (800) 918-8270

Not applicable
(Former Name or Former Address, if Changed Since Last Report)

Check the appropriate box below if the Form 8-K filing is intended to simultaneously satisfy the filing obligation of the registrant under any of the following provisions (see General Instruction A.2. below):

☐ Written communications pursuant to Rule 425 under the Securities Act (17 CFR 230.425)
☐ Soliciting material pursuant to Rule 14a-12 under the Exchange Act (17 CFR 240.14a-12)
☐ Pre-commencement communications pursuant to Rule 14d-2(b) under the Exchange Act (17 CFR 240.14d-2(b))
☐ Pre-commencement communications pursuant to Rule 13e-4(c) under the Exchange Act (17 CFR 240.13e-4(c))

Securities registered pursuant to Section 12(b) of the Act

Title of each class	Trading Symbol(s)	Name of each exchange on which registered
Common Stock, par value $0.01 per share	MOS	New York Stock Exchange

Indicate by check mark whether the registrant is an emerging growth company as defined in Rule 405 of the Securities Act of 1933 or Rule 12b-2 of the Securities Exchange Act of 1934.

☐ Emerging growth company

If an emerging growth company, indicate by check mark if the registrant has elected not to use the extended transition period for complying with any new or revised financial accounting standards provided pursuant to Section 13(a) of the Exchange Act. ☐

Item 2.02. Results of Operations and Financial Condition.

The following information is being "furnished" in accordance with General Instruction B.2. of Form 8-K and shall not be deemed "filed" for purposes of Section 18 of the Securities Exchange Act of 1934, as amended (the "Exchange Act"), or otherwise subject to the liabilities of that section, nor shall it be deemed to be incorporated by reference in any filing under the Securities Act of 1933, as amended (the "Securities Act"), or the Exchange Act, except as expressly set forth by specific reference in such filing:

Furnished herewith as Exhibit 99.1 and incorporated by reference herein is the text of The Mosaic Company's ("Mosaic," and Mosaic and its subsidiaries, individually or in any combination, "we," "us" or "our") announcement regarding its earnings and results of operations for the quarter and full year ended December 31, 2023, as presented in a press release issued on February 21, 2024.

Furnished herewith as Exhibit 99.2 and incorporated by reference herein is certain performance data for the period ended December 31, 2023 to be published on Mosaic's website.

Item 9.01. Financial Statements and Exhibits.

(d) Exhibits.

Reference is made to the Exhibit Index hereto with respect to the exhibits furnished herewith. The following exhibits are being "furnished" in accordance with General Instruction B.2. of Form 8-K and shall not be deemed "filed" for purposes of Section 18 of the Exchange Act, or otherwise subject to the liabilities of that section, nor shall they be deemed to be incorporated by reference in any filing under the Securities Act or the Exchange Act, except as expressly set forth by specific reference in such filing.

Exhibit No.	Description
99.1	Press release, dated February 21, 2024, of The Mosaic Company regarding its earnings and results of operations for the quarter and full year ended December 31, 2023
99.2	Performance data for the period ended December 31, 2023

SIGNATURES

Pursuant to the requirements of the Securities Exchange Act of 1934, the registrant has duly caused this report to be signed on its behalf by the undersigned hereunto duly authorized.

THE MOSAIC COMPANY

Date: February 21, 2024

By: /s/ Philip E. Bauer
Name: Philip E. Bauer
Title: Senior Vice President, General Counsel and Corporate Secretary

Exhibit 99.1

The Mosaic Company
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For Immediate Release

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THE MOSAIC COMPANY REPORTS FOURTH QUARTER AND FULL YEAR 2023 RESULTS

- ***Full year net income of $1.2 billion, adjusted EBITDA(1) of $2.8 billion***
- ***2023 cash from operations of $2.4 billion, free cash flow(1) of $795 million***
- ***Returned $1.1 billion to shareholders through share repurchases and dividends in 2023 and completed refinancing of $900 million in debt***
- ***Responding to current potash market conditions by curtailing production from the Colonsay mine***

TAMPA, FL, February 21, 2024 - The Mosaic Company (NYSE: MOS) today reported net income of $1.2 billion and diluted earnings per share (EPS) of $3.50 for full year 2023. Adjusted EBITDA(1) for the year was $2.8 billion and adjusted diluted EPS(1) was $3.57.

The company reported fourth quarter net income of $365 million and diluted EPS of $1.11. Adjusted EBITDA(1) totaled $646 million for the quarter and adjusted diluted EPS(1) was $0.71.

"Mosaic successfully navigated a highly dynamic market in 2023. We delivered strong free cash flow and returned significant capital to shareholders while reinvesting in the business" said Bruce Bodine, President and CEO. "Looking into 2024, Mosaic expects to continue to benefit from a strong phosphates market, and is well positioned to deliver solid results as we optimize our low cost potash operations. In addition, we are focused on improving our phosphates production level, expanding our portfolio of value-added products, growing our leading presence in Brazil, and enhancing the overall efficiency of our operations".

Highlights:

- Full year revenues declined 28 percent year-over-year to $13.7 billion, reflecting the impact of lower selling prices. The gross margin rate in 2023 was 16 percent, down from 30 percent in 2022.
- Net Income in 2023 totaled $1.2 billion, declining 67 percent from 2022. Adjusted EBITDA(1) in 2023 totaled $2.8 billion, a decline of 56 percent from 2022. Cash flows from operating activities totaled $2.4 billion and Free Cash Flow(1) totaled $795 million.
- Potash operating earnings were $1.2 billion in 2023, down from $2.8 billion in the prior year. Adjusted EBITDA(1) totaled $1.5 billion in 2023, down from $3.1 billion last year. We completed the development of Esterhazy K3, which is the largest and one of the most efficient and low-cost potash complexes in the world. Canpotex's port at Portland, Oregon returned to normal operation in December after being idled since April 2023. In response to current market conditions, Mosaic will be curtailing its production from its Colonsay mine.

(1)See "Non-GAAP Financial Measures" for additional information and reconciliation.

*Free cash flow is defined as cash from operations minus total capital expenditures and adjusted for working capital financing.

- Phosphate operating earnings were $375 million in 2023, compared to $1.3 billion in 2022. Adjusted EBITDA(1) totaled $1.2 billion in 2023, down from $2.2 billion in the prior year. Segment results reflect the impact of lower prices and production challenges due to weather-related events and repairs of our sulfuric acid facilities in Louisiana, partially offset by lower raw material prices. Phosphate prices stabilized in the second quarter of 2023 and rose in the second half of the year.

- Mosaic Fertilizantes operating earnings were $75 million in 2023, down from $910 million in 2022. Adjusted EBITDA(1) totaled $327 million in 2023, down from $1.0 billion last year. In the second quarter of 2023, we finished the destocking of high-priced inventory which negatively impacted our first half 2023 results. Distribution business margin per tonne came in above the $30-$40 annual normalized range in the fourth quarter.

Capital Allocation Strategy

Mosaic remains committed to a disciplined capital allocation strategy.

- Mosaic returned $1.1 billion of capital to shareholders in 2023, including share repurchases totaling $756 million, and increased the dividend by 10 percent in December 2023. Capital returns exceeded free cash flow due to cash received from other sources, including the sale of Streamsong Resort.

- Mosaic is committed to maintaining a strong balance sheet that is sustainable through our industry's normal business cycle. Mosaic refinanced $900 million of debt obligations with a $500 million term loan, and a $400 million bond issuance which closed in December.

- Mosaic remains committed to returning excess cash to shareholders in 2024 through a combination of dividends and share repurchases.

- Total capital expenditures are expected to be approximately $1.2 billion for 2024, about $200 million below the 2023 level. Mosaic continues to focus on high-returning investments with modest capital requirements.

Segment Analysis

Potash	Q4 2023	Q4 2022	2023	2022
Sales Volumes - million tonnes*	2.6	1.9	8.9	8.1
MOP Selling Price(2)	$243	$581	$308	$632
Gross Margin (GAAP) per tonne	$99	$289	$137	$351
Adjusted Gross Margin (non-GAAP) per tonne(1)	$99	$289	$137	$351
Operating Earnings - millions	$222	$497	$1,152	$2,768
Segment Adjusted EBITDA(1) - millions	$322	$597	$1,471	$3,117

*Tonnes = finished product tonnes
(2)Average per tonne MOP selling price (fob mine)

The Potash segment reported net sales of $3.2 billion in 2023, down from $5.2 billion in 2022, reflecting lower prices. Gross margin per tonne was $137, down from $351 last year.

Sales volumes increased from 8.1 million tonnes in 2022 to 8.9 million tonnes in 2023. Despite logistics challenges, fourth quarter sales volumes came in well within our guidance range.

Sales volumes in the first quarter are expected to be 2.0-2.2 million tonnes with realized mine-gate MOP prices in the range of $225-$250 per tonne.

(1)See “Non-GAAP Financial Measures” for additional information and reconciliation.

Phosphate	Q4 2023	Q4 2022	2023	2022
Sales Volumes - million tonnes*	1.6	1.6	7.0	6.6
DAP Selling Price[3]	$552	$722	$573	$804
Gross Margin (GAAP) per tonne	$88	$148	$100	$268
Adjusted Gross Margin (non-GAAP) per tonne[1]	$106	$167	$109	$274
Operating Earnings (Loss) - millions	$21	$145	$375	$1,347
Segment Adjusted EBITDA[1] - millions	$259	$348	$1,227	$2,219

*Tonnes = finished product tonnes
[3]Average DAP Selling Price (fob plant)

Net sales in the Phosphate segment decreased to $4.7 billion in 2023, down from $6.2 billion in 2022, driven by lower selling prices in 2023. Sales volumes increased from 6.6 million tonnes in 2022 to 7.0 million tonnes, while production volume of finished phosphates totaled 6.6 million, down from 6.7 million.

The average realized selling price decreased to $646 per tonne in 2023, from $913 in 2022. Gross margin per tonne was $100 in 2023, compared to $268 in 2022, and adjusted gross margin per tonne[1] decreased to $109 in 2023 from $274 in the prior year, reflecting lower phosphate prices which were partially offset by the decrease in raw material costs.

Sales volumes in the first quarter are expected to be 1.6-1.8 million tonnes with DAP prices on an FOB basis averaging $580-$605 per tonne. Stripping margins are expected to stay elevated.

Mosaic Fertilizantes	Q4 2023	Q4 2022	2023	2022
Sales Volumes - million tonnes*	2.2	2.5	9.7	9.4
Finished Product Selling Price	$552	$773	$587	$878
Gross Margin (GAAP) per tonne	$44	$11	$22	$111
Adjusted Gross Margin per tonne[1]	$45	$12	$24	$111
Operating Earnings - millions	$50	$(20)	$75	$910
Segment Adjusted EBITDA[1] - millions	$111	$29	$327	$1,049

*Tonnes = finished product tonnes

Mosaic Fertilizantes reported net sales of $5.7 billion in 2023, down from $8.3 billion in the prior year, reflecting lower prices. The gross margin per tonne, which averaged $22 in 2023, down from $111 in 2022, was negatively impacted by lower prices, inflationary cost pressures and high-priced inventory. The destocking of high-priced inventory was complete in the second quarter of 2023 and margin per tonne of the distribution business in the fourth quarter was above the historical normalized annual range of $30-$40 per tonne.

The distribution business typically sells more nitrogen products in the first quarter of each year, which historically generate lower and less consistent margins. As such, we expect first quarter margin per tonne will be below the historical normalized annual range. We expect distribution margin per tonne in a twelve-month period ended March 31, 2024 to be within the normalized annual range.

Other

Full-year selling, general and administrative expenses were $501 million in 2023 compared with $498 million in 2022.

Mosaic recognized strong earnings from equity investments of $60 million, reflecting contribution from the company's share of the MWSPC joint venture in Saudi Arabia.

[1]See "Non-GAAP Financial Measures" for additional information and reconciliation.

The reported effective tax rate for 2023 was 13.3 percent, and 26.9 percent excluding discrete items. Cash taxes paid in 2023 were $386 million.

In 2023, net cash provided by operating activities was $2.4 billion and capital expenditures were $1.4 billion.

2024 Market Outlook

Global grain and oilseed markets are expected to remain tight in 2024. Crop production, threatened by geopolitical unrest, weather extremes and reduced fertilization, is struggling to keep up with strong demand driven by secular demographic changes and growing consumption from renewable fuels. As a result, global stocks-to-use ratios for grains and oilseeds are expected to remain under pressure for the foreseeable future. Today's healthy agriculture back drop and favorable economics will continue to incentivize growers to maximize yields and apply fertilizers.

These demand factors are especially promising for the phosphate market as they are expected to be matched by tight global supply well into 2024. China's exports are expected to remain capped as domestic agriculture and industrial demand is prioritized over fertilizer exports. Firm phosphate prices and low raw material prices suggest that stripping margins will stay elevated for the foreseeable future.

In North America, after a long Fall application season and solid winter fill activities, demand strength continues into the Spring planting season. Brazil shipments are expected to remain solid in 2024 as barter ratio are favorable and growers need to replenish soil nutrients. In India, grower demand is strong and growers are waiting for higher government subsidy rates.

Potash demand for North America is expected to remain robust in 2024, and demand in Southeast Asia and Brazil is expected to improve as the year progresses. Supply appears adequate to meet that demand in the near term.

2024 Modeling Assumptions

The Company provides the following modeling assumptions for the full year 2024:

Modeling Assumptions	Full Year 2024
Total Capital Expenditures	$1.1 - 1.2 billion
Depreciation, Depletion & Amortization	$960 - $990 million
Selling, General, and Administrative Expense	$470 - $500 million
Net Interest Expense	$140 - $160 million
Effective tax rate	High 20's %
Cash tax rate	Mid 20's %

Sensitivities Table Using 2023 Cost Structure

The Company provided the following sensitivities to price and foreign exchange rates to help investors anticipate the potential impact of movements in these factors.

Sensitivity	Full year adj. EBITDA impact(1)	2023 Actual
Average MOP Price / tonne (fob mine)(5)	$10/mt price change = $60 million (4)	$308
Average DAP Price / tonne (fob plant)(5)	$10/mt price change = $70 million	$573
Average BRL / USD	0.10 change, unhedged = $10 million(6)	5.00

(4) Includes impact of Canadian Resource Tax

(5) Approximately 20% of DAP price sensitivity impact is expected to be in the Mosaic Fertilizantes segment.; approximately 5% of the MOP price sensitivity impact is expected to be in the Mosaic Fertilizantes segment.

(6) The company hedged about 50 percent of the annual sensitivity. Over longer periods of time, inflation is expected to offset a portion of currency benefits.

About The Mosaic Company
The Mosaic Company is one of the world's leading producers and marketers of concentrated phosphate and potash crop nutrients. Mosaic is a single-source provider of phosphate and potash fertilizers and feed ingredients for the global agriculture industry. More information on the company is available at www.mosaicco.com.

Mosaic will conduct a conference call on Thursday, February 22, 2024, at 11:00 a.m. Eastern Time to discuss fourth quarter and full year 2023 earnings results. A simultaneous webcast of the conference call may be accessed through Mosaic's website at www.mosaicco.com/investors. This webcast will be available up to one year from the time of the earnings call.

This release contains forward-looking statements within the meaning of the Private Securities Litigation Reform Act of 1995. Such statements may include, but are not limited to, statements about proposed or pending common dividends, special dividends, share repurchases, future transactions or strategic plans and other statements about future financial and operating results. Such statements are based upon the current beliefs and expectations of The Mosaic Company's management and are subject to significant risks and uncertainties. These risks and uncertainties include, but are not limited to: political and economic instability and changes in government policies in countries in which we have operations; the predictability and volatility of, and customer expectations about, agriculture, fertilizer, raw material, energy and transportation markets that are subject to competitive and other pressures and economic and credit market conditions; the level of inventories in the distribution channels for crop nutrients; the effect of future product innovations or development of new technologies on demand for our products; changes in foreign currency and exchange rates; international trade risks and other risks associated with Mosaic's international operations and those of joint ventures in which Mosaic participates, including the performance of the Wa'ad Al Shamal Phosphate Company (also known as MWSPC), the future success of current plans for MWSPC and any future changes in those plans; difficulties with realization of the benefits of our natural gas based pricing ammonia supply agreement with CF Industries, Inc., including the risk that the cost savings initially anticipated from the agreement may not be fully realized over its term or that the price of natural gas or ammonia during the term are at levels at which the pricing is disadvantageous to Mosaic; customer defaults; the effects of Mosaic's decisions to exit business operations or locations; changes in government policy; changes in environmental and other governmental regulation, including expansion of the types and extent of water resources regulated under federal law, carbon taxes or other greenhouse gas regulation, implementation of numeric water quality standards for the discharge of nutrients into Florida waterways or efforts to reduce the flow of excess nutrients into the Mississippi River basin, the Gulf of Mexico or elsewhere; further developments in judicial or administrative proceedings, or complaints that Mosaic's operations are adversely impacting nearby farms, business operations or properties; difficulties or delays in receiving, increased costs of or challenges to necessary governmental permits or approvals or increased financial assurance requirements; resolution of global tax audit activity; the effectiveness of Mosaic's processes for managing its strategic priorities; adverse weather conditions affecting operations in Central Florida, the Mississippi River basin, the Gulf Coast of the United States, Canada or Brazil, and including potential hurricanes, excess heat, cold, snow, rainfall or drought; actual costs of various items differing from management's current estimates, including, among others, asset retirement, environmental remediation, reclamation or other environmental regulation, Canadian resources taxes and royalties, or the costs of the MWSPC; reduction of Mosaic's available cash and liquidity, and increased leverage, due to its use of cash and/or available debt capacity to fund financial assurance requirements and strategic investments; brine inflows at Mosaic's potash mines; other accidents and disruptions involving Mosaic's operations, including potential mine fires, floods, explosions, seismic events, sinkholes or releases of hazardous or volatile chemicals; and risks associated with cyber security, including reputational loss; as well as other risks and uncertainties reported from time to time in The Mosaic Company's reports filed with the Securities and Exchange Commission. Actual results may differ from those set forth in the forward-looking statements. The declarations and payment of future dividends and special dividends remain at the discretion of the Board of Directors.

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Non-GAAP Financial Measures
This press release includes the presentation and discussion of non-GAAP diluted net earnings per share guidance, or adjusted EPS, non-GAAP gross margin per tonne, or adjusted gross margin per tonne, non-GAAP adjusted EBITDA, and free cash flow, collectively referred to as non-GAAP financial measures. Generally, a non-GAAP financial measure is a supplemental numerical measure of a company's performance, financial position or cash flows that either excludes or includes amounts that are not normally excluded or included in the most directly comparable measure calculated and presented in accordance with U.S. generally accepted accounting principles, or GAAP. Non-GAAP financial measures should not be considered as substitutes for, or superior to, measures of financial performance prepared in accordance with GAAP. In addition, because non-GAAP measures are not determined in accordance with GAAP, they are thus susceptible to varying interpretations and calculations and may not be comparable to other similarly titled measures of other companies. Adjusted metrics, including adjusted EPS, adjusted gross margin, and adjusted EBITDA are calculated by excluding the impact of notable items from the GAAP measure. Notable items impact on gross margin and EBITDA is pretax. Notable items impact on diluted net earnings per share is calculated as the notable item amount plus income tax effect, based on expected annual effective tax rate, divided by diluted weighted average shares. Management believes that these adjusted measures provide securities analysts, investors, management and others with useful supplemental information regarding our performance by excluding certain items that may not be indicative of, or are unrelated to, our core operating results. Free Cash Flow is defined as net cash provided by operating activities less capital expenditures and adjusted for changes in working capital financing. Management utilizes these adjusted measures in analyzing

and assessing Mosaic's overall performance and financial trends, for financial and operating decision-making, and to forecast and plan for future periods. These adjusted measures also assist our management in comparing our and our competitors' operating results. We are not providing forward looking guidance for U.S. GAAP reported diluted net earnings per share, gross margin per tonne, or a quantitative reconciliation of forward-looking adjusted EPS, adjusted gross margin and adjusted EBITDA because we are unable to predict with reasonable certainty our notable items without unreasonable effort. Historically, our notable items have included, but are not limited to, foreign currency transaction gain or loss, unrealized gain or loss on derivatives, acquisition-related fees, discrete tax items, contingencies and certain other gains or losses. These items are uncertain, depend on various factors, and could have a material impact on U.S. GAAP reported results for the guidance period. Reconciliations for Non-GAAP financial measures contained in this press release are found below. Reconciliations for current and historical periods beginning with the quarter ended March 31, 2022 for consolidated adjusted EPS and adjusted EBITDA, as well as segment adjusted EBITDA and adjusted gross margin per tonne are provided in the Selected Calendar Quarter Financial Information performance data for the related periods. This information is being furnished under Exhibit 99.2 of the Form 8-K and available on our website at www.mosaicco.com in the "Financial Information - Quarterly Earnings" section under the "Investors" tab.

For the three months ended December 31, 2023, the Company reported the following notable items which, combined, positively impacted earnings per share by $0.40:

Description	Segment	Line item	Amount (in millions)	Tax effect (in millions)	EPS impact (per share)
Foreign currency transaction gain (loss)	Consolidated	Foreign currency transaction gain (loss)	$ 79	$ (16)	$ 0.20
Unrealized gain (loss) on derivatives	Corporate and Other	Cost of goods sold	40	(7)	0.10
Closed and indefinitely idled facility costs	Phosphate	Other operating income (expense)	(9)	2	(0.03)
FX functional currency	Mosaic Fertilizantes	Cost of goods sold	(3)	1	(0.01)
Realized gain (loss) on RCRA Trust Securities	Phosphate	Other non-operating income (expense)	(7)	2	(0.02)
ARO Adjustment	Phosphate	Other operating income (expense)	(4)	1	(0.01)
Environmental reserve	Phosphate	Other operating income (expense)	(64)	11	(0.16)
Land reclamation	Phosphate	Cost of goods sold	(28)	5	(0.07)
ARO adjustment	Potash	Other operating income (expense)	(10)	2	(0.02)
Tax law change	Mosaic Fertilizantes	(Provision for) benefit from income taxes	—	136	0.42
Total Notable Items			$ (6)	$ 137	$ 0.40

For the three months ended December 31, 2022, the Company reported the following notable items which, combined, negatively impacted earnings per share by $0.22:

Description	Segment	Line item	Amount (in millions)	Tax effect (in millions)	EPS impact (per share)
Foreign currency transaction gain (loss)	Consolidated	Foreign currency transaction gain (loss)	$ 75	$ (18)	$ 0.16
Unrealized gain (loss) on derivatives	Corporate and Other	Cost of goods sold	14	(4)	0.03
Closed and indefinitely idled facility costs	Phosphate	Other operating income (expense)	(11)	3	(0.03)
FX functional currency	Mosaic Fertilizantes	Cost of goods sold	(1)	—	—
Fixed asset write-off	Phosphate	Other operating income (expense)	(6)	2	(0.01)
ARO Adjustment	Potash	Other operating income (expense)	3	(1)	0.01
Discrete tax items	Consolidated	(Provision for) benefit from income taxes	—	(9)	(0.03)
Realized gain (loss) on RCRA Trust Securities	Phosphates	Other non-operating income (expense)	(20)	5	(0.04)
Environmental reserve	Phosphates	Other operating income (expense)	(44)	11	(0.09)
Hurricane Ian idle costs	Phosphates	Cost of goods sold	(30)	8	(0.07)
Insurance proceeds	Phosphates	Other operating income (expense)	5	(1)	0.01
Pension plan termination settlement	Consolidated	Other non-operating income (expense)	(42)	10	(0.09)
Environmental reserve	Potash	Other operating income (expense)	(28)	7	(0.06)
Lease termination and severance	Corporate and Other	Other operating income (expense)	(4)	1	(0.01)
Total Notable Items			$ (89)	$ 14	$ (0.22)

Condensed Consolidated Statements of Earnings
(in millions, except per share amounts)

The Mosaic Company **(unaudited)**

	Three months ended December 31,		Years ended December 31,	
	2023	2022	2023	2022
Net sales	$ 3,149.5	$ 4,481.3	$ 13,696.1	$ 19,125.2
Cost of goods sold	2,590.0	3,512.9	11,485.5	13,369.4
Gross margin	559.5	968.4	2,210.6	5,755.8
Selling, general and administrative expenses	123.0	132.9	500.5	498.0
Other operating expenses	158.0	134.9	372.0	472.5
Operating earnings	278.5	700.6	1,338.1	4,785.3
Interest expense, net	(34.9)	(33.8)	(129.4)	(137.8)
Foreign currency transaction gain (loss)	91.0	75.1	194.0	97.5
Other (expense) income	(10.7)	(64.7)	(76.8)	(102.5)
Earnings from consolidated companies before income taxes	323.9	677.2	1,325.9	4,642.5
Provision for (benefit from) income taxes	(43.8)	206.0	177.0	1,224.3
Earnings from consolidated companies	367.7	471.2	1,148.9	3,418.2
Equity in net earnings of nonconsolidated companies	0.3	57.3	60.3	196.0
Net earnings including noncontrolling interests	368.0	528.5	1,209.2	3,614.2
Less: Net earnings attributable to noncontrolling interests	2.7	5.3	44.3	31.4
Net earnings attributable to Mosaic	$ 365.3	$ 523.2	$ 1,164.9	$ 3,582.8
Diluted net earnings per share attributable to Mosaic	$ 1.11	$ 1.52	$ 3.50	$ 10.06
Diluted weighted average number of shares outstanding	327.7	343.8	333.2	356.0

Condensed Consolidated Balance Sheets
(in millions, except per share amounts)

The Mosaic Company **(unaudited)**

	December 31, 2023	December 31, 2022
Assets		
Current assets:		
Cash and cash equivalents	$ 348.8	$ 735.4
Receivables, net	1,269.2	1,699.9
Inventories	2,523.2	3,543.1
Other current assets	603.8	578.2
Total current assets	4,745.0	6,556.6
Property, plant and equipment, net	13,585.4	12,678.7
Investments in nonconsolidated companies	909.0	885.9
Goodwill	1,138.6	1,116.3
Deferred income taxes	1,079.2	752.3
Other assets	1,575.6	1,396.2
Total assets	$ 23,032.8	$ 23,386.0
Liabilities and Equity		
Current liabilities:		
Short-term debt	$ 399.7	$ 224.9
Current maturities of long-term debt	130.1	985.3
Structured accounts payable arrangements	399.9	751.2
Accounts payable	1,166.9	1,292.5
Accrued liabilities	1,777.1	2,279.9
Total current liabilities	3,873.7	5,533.8
Long-term debt, less current maturities	3,231.6	2,411.9
Deferred income taxes	1,065.5	1,010.1
Other noncurrent liabilities	2,429.2	2,236.0
Equity:		
Preferred stock, $0.01 par value, 15,000,000 shares authorized, none issued and outstanding as of December 31, 2023 and 2022	—	—
Common stock, $0.01 par value, 1,000,000,000 shares authorized, 393,875,241 shares issued and 324,103,141 shares outstanding as of December 31, 2023, 391,964,464 shares issued and 339,071,423 shares outstanding as of December 31, 2022	3.2	3.4
Capital in excess of par value	—	—
Retained earnings	14,241.9	14,203.4
Accumulated other comprehensive loss	(1,954.9)	(2,152.2)
Total Mosaic stockholders' equity	12,290.2	12,054.6
Non-controlling interests	142.6	139.6
Total equity	12,432.8	12,194.2
Total liabilities and equity	$ 23,032.8	$ 23,386.0

Condensed Consolidated Statements of Cash Flows
(in millions, except per share amounts)

The Mosaic Company **(unaudited)**

	Three months ended December 31,		Years ended December 31,	
	2023	2022	2023	2022
Cash Flows from Operating Activities:				
Net cash provided by operating activities	$ 538.1	$ 955.7	$ 2,407.2	$ 3,935.8
Cash Flows from Investing Activities:				
Capital expenditures	(358.9)	(340.5)	(1,402.4)	(1,247.3)
Purchases of available-for-sale securities - restricted	(201.1)	(302.9)	(1,240.8)	(762.5)
Proceeds from sale of available-for-sale securities - restricted	197.4	298.4	1,209.1	743.0
Proceeds from sale of business	—	—	158.4	—
Acquisition of business	—	—	(41.0)	—
Other	0.4	1.9	(0.5)	7.2
Net cash used in investing activities	(362.2)	(343.1)	(1,317.2)	(1,259.6)
Cash Flows from Financing Activities:				
Payments of short-term debt	(3,070.1)	(1,602.6)	(9,832.0)	(1,761.2)
Proceeds from issuance of short-term debt	3,170.0	1,827.7	10,007.1	1,980.5
Payments from inventory financing arrangement	—	(200.5)	(601.4)	(1,651.5)
Proceeds from inventory financing arrangement	—	—	601.4	1,348.8
Payments of structured accounts payable arrangements	(422.3)	(332.5)	(1,432.9)	(1,476.6)
Proceeds from structured accounts payable arrangements	214.2	439.9	1,048.2	1,460.5
Payments of long-term debt	(950.5)	(565.8)	(995.3)	(610.3)
Proceeds from issuance of long-term debt	900.0	—	900.0	—
Collections of transferred receivables	—	1,068.5	1,468.6	2,352.1
Payments of transferred receivables	—	(1,069.7)	(1,468.6)	(2,433.2)
Repurchases of stock	(150.0)	(64.0)	(756.0)	(1,665.2)
Cash dividends paid	(65.1)	(51.1)	(351.6)	(197.7)
Dividends paid to non-controlling interest	(17.8)	(21.3)	(41.5)	(38.0)
Other	(19.1)	(1.6)	(26.5)	13.1
Net cash used in financing activities	(410.7)	(573.0)	(1,480.5)	(2,678.7)
Effect of exchange rate changes on cash	(6.2)	(8.0)	(2.8)	(29.7)
Net change in cash, cash equivalents and restricted cash	(241.0)	31.6	(393.3)	(32.2)
Cash, cash equivalents and restricted cash—beginning of year	601.8	722.5	754.1	786.3
Cash, cash equivalents and restricted cash—end of year	$ 360.8	$ 754.1	$ 360.8	$ 754.1

	Years ended December 31,	
	2023	2022
Reconciliation of cash, cash equivalents and restricted cash reported within the consolidated balance sheets to the consolidated statements of cash flows:		
Cash and cash equivalents	$ 348.8	$ 735.4
Restricted cash in other current assets	8.6	8.2
Restricted cash in other assets	3.4	10.5
Total cash, cash equivalents and restricted cash shown in the statement of cash flows	$ 360.8	$ 754.1

Reconciliation of Non-GAAP Financial Measures

Earnings Per Share Calculation

	Three months ended December 31,		Years ended December 31,	
	2023	2022	2023	2022
Net earnings attributed to Mosaic	$ 365.3	$ 523.2	$ 1,164.9	$ 3,582.8
Basic weighted average number of shares outstanding	326.1	340.3	331.3	352.4
Dilutive impact of share-based awards	1.6	3.5	1.9	3.6
Diluted weighted average number of shares outstanding	327.7	343.8	333.2	356.0
Basic net earnings per share	$ 1.12	$ 1.54	$ 3.52	$ 10.17
Diluted net earnings per share	$ 1.11	$ 1.52	$ 3.50	$ 10.06
Notable items impact on earnings per share	$ (0.40)	$ 0.22	$ 0.07	$ 0.95
Adjusted earnings per share	$ 0.71	$ 1.74	$ 3.57	$ 11.01

Free Cash Flow

	Year ended December 31,	
	2023	2022
Net cash provided by operating activities	$ 2,407	$ 3,936
Capital expenditures	(1,402)	(1,247)
Working capital financing[a]	(210)	(95)
Free cash flow	$ 795	$ 2,594

[a] Includes net proceeds (payments) from inventory financing arrangements, structured accounts payable arrangements and commercial paper borrowings.

Reconciliation of Non-GAAP Financial Measures

Consolidated Earnings *(in millions)*	**Three months ended December 31,**	**Year ended December 31,**
	2023	**2023**
Consolidated net earnings attributable to Mosaic	$ 365	$ 1,165
Less: Consolidated interest expense, net	(35)	(129)
Plus: Consolidated depreciation, depletion and amortization	257	960
Plus: Accretion expense	27	96
Plus: Share-based compensation expense	6	33
Plus: Consolidated provision for (benefit from) income taxes	(44)	176
Less: Equity in net earnings of nonconsolidated companies, net of dividends	—	35
Plus: Notable items not included above	—	237
Adjusted EBITDA	$ 646	$ 2,761

Potash Earnings *(in millions)*	**Three months ended December 31,**		**Years ended December 31,**	
	2023	**2022**	**2023**	**2022**
Operating Earnings	$ 222	$ 497	$ 1,152	$ 2,768
Plus: Depreciation, Depletion and Amortization	89	73	299	307
Plus: Accretion Expense	3	2	9	8
Plus: Foreign Exchange Gain (Loss)	41	6	41	(19)
Plus: Other Non Operating Income	(2)	—	(45)	—
Plus: Notable Items	(31)	19	15	53
Adjusted EBITDA	$ 322	$ 597	$ 1,471	$ 3,117

Phosphate Earnings *(in millions)*	**Three months ended December 31,**		**Years ended December 31,**	
	2023	**2022**	**2023**	**2022**
Operating Earnings	$ 21	$ 145	$ 375	$ 1,347
Plus: Depreciation, Depletion and Amortization	124	111	486	485
Plus: Accretion Expense	19	15	67	55
Plus: Foreign Exchange Gain (Loss)	(1)	(4)	(1)	(8)
Plus: Other Non Operating Income (Expense)	(9)	(9)	(16)	(32)
Plus: Dividends from equity investments	—	—	25	—
Less: Earnings (Loss) from Consolidated Noncontrolling Interests	2	5	47	32
Plus: Notable Items	107	95	338	404
Adjusted EBITDA	$ 259	$ 348	$ 1,227	$ 2,219

Reconciliation of Non-GAAP Financial Measures

Mosaic Fertilizantes *(in millions)*	**Three months ended December 31,**		**Years ended December 31,**	
	2023	**2022**	**2023**	**2022**
Operating Earnings	$ 50	$ (20)	$ 75	$ 910
Plus: Depreciation, Depletion and Amortization	41	45	165	125
Plus: Accretion Expense	5	5	20	17
Plus: Foreign Exchange Gain (Loss)	32	38	80	8
Plus: Other Non Operating Income (Expense)	(1)	(1)	(4)	(4)
Less: Earnings (Loss) from Consolidated Noncontrolling Interests	—	—	(2)	(1)
Plus: Notable Items	(16)	(38)	(11)	(8)
Adjusted EBITDA	$ 111	$ 29	$ 327	$ 1,049

Potash Earnings *(in millions)*	**Three months ended December 31,**		**Years ended December 31,**	
	2023	**2022**	**2023**	**2022**
Gross Margin / tonne	$ 99	$ 289	$ 137	$ 351
Notable items in gross margin	—	—	—	—
Adjusted gross margin / tonne	$ 99	$ 289	$ 137	$ 351

Phosphates Earnings *(in millions)*	**Three months ended December 31,**		**Years ended December 31,**	
	2023	**2022**	**2023**	**2022**
Gross Margin / tonne	$ 88	$ 148	$ 100	$ 268
Notable items in gross margin	18	19	9	6
Adjusted gross margin / tonne	$ 106	$ 167	$ 109	$ 274

Mosaic Fertilizantes Earnings *(in millions)*	**Three months ended December 31,**		**Years ended December 31,**	
	2023	**2022**	**2023**	**2022**
Gross Margin / tonne	$ 44	$ 11	$ 22	$ 111
Notable items in gross margin	1	1	2	—
Adjusted gross margin / tonne	$ 45	$ 12	$ 24	$ 111

Exhibit 99.2

The Mosaic Company
Selected Calendar Quarter Financial Information
(Unaudited)

	Q1 2022	Q2 2022	Q3 2022	Q4 2022	Q1 2023	Q2 2023	Q3 2023	Q4 2023
Consolidated data *(in millions, except per share)*								
Diluted net earnings (loss) per share	**$ 3.19**	**$ 2.85**	**$ 2.42**	**$ 1.52**	**$ 1.28**	**$ 1.11**	**$ (0.01)**	**$ 1.11**
Notable items impact on earnings per share[a]	0.78	(0.79)	(0.80)	(0.22)	0.14	0.07	(0.69)	0.40
Adjusted diluted net earnings per share[a]	$ 2.41	$ 3.64	$ 3.22	$ 1.74	$ 1.14	$ 1.04	$ 0.68	$ 0.71
Diluted weighted average # of shares outstanding	370.1	363.1	347.7	343.8	338.7	333.7	332.0	327.7
Total Net Sales	**$ 3,922**	**$ 5,373**	**$ 5,348**	**$ 4,481**	**$ 3,604**	**$ 3,395**	**$ 3,548**	**$ 3,149**
Cost of goods sold	2,483	3,526	3,846	3,512	2,934	2,824	3,139	2,589
Gross Margin	**$ 1,439**	**$ 1,847**	**$ 1,502**	**$ 969**	**$ 670**	**$ 571**	**$ 409**	**$ 560**
SG&A	133	108	124	133	127	130	120	123
Other operating (income) expense[p]	50	65	224	136	(2)	72	144	158
Operating earnings	**$ 1,256**	**$ 1,674**	**$ 1,154**	**$ 700**	**$ 545**	**$ 369**	**$ 145**	**$ 279**
Interest expense, net	(40)	(34)	(31)	(34)	(41)	(36)	(17)	(35)
Consolidated foreign currency gain/(loss)	311	(227)	(61)	75	51	149	(97)	91
Earnings from consolidated companies before income taxes	**1,527**	**1,377**	**1,061**	**677**	**546**	**474**	**(19)**	**324**
Provision for (benefit from) income taxes	372	369	277	206	118	108	(6)	(44)
Earnings (loss) from consolidated companies	**$ 1,155**	**$ 1,008**	**$ 784**	**$ 471**	**$ 428**	**$ 366**	**$ (13)**	**$ 368**
Equity in net earnings (loss) of nonconsolidated companies	31	36	72	57	31	13	16	—
Less: Net earnings (loss) attributable to noncontrolling interests	4	8	14	5	24	10	7	3
Net earnings (loss) attributable to Mosaic	**$ 1,182**	**$ 1,036**	**$ 842**	**$ 523**	**$ 435**	**$ 369**	**$ (4)**	**$ 365**
After tax Notable items included in earnings	$ 288	$ (286)	$ (277)	$ (75)	$ 46	$ 22	$ (231)	$ 131
Gross Margin Rate	*37 %*	*34 %*	*28 %*	*22 %*	*19 %*	*17 %*	*12 %*	*18 %*
Effective Tax Rate (including discrete tax)	*24 %*	*27 %*	*26 %*	*30 %*	*22 %*	*23 %*	*32 %*	*(14)%*
Discrete Tax benefit (expense)	$ 9	$ (14)	$ (12)	$ (9)	$ 14	$ 10	$ 17	$ 2
Depreciation, Depletion and Amortization	$ 226	$ 245	$ 229	$ 233	$ 220	$ 244	$ 239	$ 257
Accretion Expense	$ 20	$ 20	$ 19	$ 22	$ 23	$ 23	$ 23	$ 27
Share-Based Compensation Expense	$ 16	$ (1)	$ 6	$ 6	$ 12	$ 9	$ 6	$ 6
Notable Items	$ (374)	$ 361	$ 354	$ 84	$ (66)	$ (32)	$ 335	$ —
Adjusted EBITDA[b]	**$ 1,451**	**$ 2,028**	**$ 1,686**	**$ 1,051**	**$ 777**	**$ 744**	**$ 594**	**$ 646**
Net cash provided by (used in) operating activities	$ 506	$ 1,585	$ 889	$ 956	$ 149	$ 1,073	$ 647	$ 538
Cash paid for interest (net of amount capitalized)	4	80	3	83	8	80	5	76
Cash paid for income taxes (net of refunds)	259	233	253	370	226	147	49	(36)
Net cash used in investing activities	$ (297)	$ (265)	$ (355)	$ (343)	$ (221)	$ (312)	$ (422)	$ (362)
Capital expenditures	(291)	(263)	(354)	(341)	(322)	(310)	(412)	(359)
Net cash (used in) provided by financing activities	$ (125)	$ (1,331)	$ (650)	$ (573)	$ (209)	$ (607)	$ (254)	$ (411)
Cash dividends paid	(41)	(54)	(51)	(51)	(152)	(68)	(66)	(65)
Effect of exchange rate changes on cash	$ 31	$ (33)	$ (20)	$ (8)	$ 4	$ 9	$ (10)	$ (6)
Net change in cash and cash equivalents	**$ 115**	**$ (44)**	**$ (135)**	**$ 32**	**$ (277)**	**$ 164**	**$ (39)**	**$ (241)**
Short-term debt	$ 481	$ 17	$ 201	$ 225	$ 855	$ 229	$ 300	$ 400
Long-term debt (including current portion)	3,977	3,960	3,959	3,397	3,389	3,393	3,357	3,362
Cash & cash equivalents	882	839	703	735	465	626	591	349
Net debt	**$ 3,576**	**$ 3,138**	**$ 3,457**	**$ 2,887**	**$ 3,779**	**$ 2,996**	**$ 3,066**	**$ 3,413**
Segment Contributions *(in millions)*								
Phosphates	$ 1,496	$ 1,801	$ 1,577	$ 1,310	$ 1,382	$ 1,286	$ 986	$ 1,070
Potash	1,060	1,580	1,432	1,136	907	849	720	758
Mosaic Fertilizantes	1,488	2,260	2,629	1,910	1,343	1,419	1,731	1,192
Corporate and Other[c]	(122)	(268)	(290)	125	(28)	(159)	111	129
Total net sales	**$ 3,922**	**$ 5,373**	**$ 5,348**	**$ 4,481**	**$ 3,604**	**$ 3,395**	**$ 3,548**	**$ 3,149**
Phosphates	$ 493	$ 578	$ 131	$ 145	$ 266	$ 146	$ (58)	$ 21
Potash	563	915	793	497	402	328	200	222
Mosaic Fertilizantes	187	420	323	(20)	(32)	(20)	77	50
Corporate and Other[c]	13	(239)	(93)	78	(91)	(85)	(74)	(14)
Consolidated operating earnings (loss)	**$ 1,256**	**$ 1,674**	**$ 1,154**	**$ 700**	**$ 545**	**$ 369**	**$ 145**	**$ 279**

Phosphates[d]	1,661	1,675	1,651	1,571	1,836	1,922	1,651	1,582
Potash[d]	1,792	2,304	2,142	1,863	1,910	2,163	2,220	2,577
Mosaic Fertilizantes	1,822	2,320	2,824	2,472	2,080	2,385	3,060	2,158
Corporate and Other	370	533	221	466	420	359	482	618
Total finished product tonnes sold *('000 tonnes)*	**5,645**	**6,832**	**6,838**	**6,372**	**6,246**	**6,829**	**7,413**	**6,935**
Sales of Performance Products (third party) ('000 tonnes) [e]	711	741	790	1,265	819	977	1,305	1,044

The Mosaic Company - Phosphates Segment
Selected Calendar Quarter Financial Information
(Unaudited)

	Q1 2022	Q2 2022	Q3 2022	Q4 2022	Q1 2023	Q2 2023	Q3 2023	Q4 2023
Net Sales and Gross Margin *(in millions, except per tonne)*								
Segment income statement								
Net Sales	**$ 1,496**	**$ 1,801**	**$ 1,577**	**$ 1,310**	**$ 1,382**	**$ 1,286**	**$ 986**	**$ 1,070**
Cost of Goods Sold	968	1,159	1,219	1,078	1,123	1,070	899	931
Gross Margin	**$ 528**	**$ 642**	**$ 358**	**$ 232**	**$ 259**	**$ 216**	**$ 87**	**$ 139**
Notable Items Included in Gross Margin	—	—	(9)	(30)	—	(31)	—	(28)
Adjusted Gross Margin[b]	**$ 528**	**$ 642**	**$ 367**	**$ 262**	**$ 259**	**$ 247**	**$ 87**	**$ 167**
SG&A	8	10	8	15	10	11	10	11
Other operating (income) expense	27	54	219	72	(17)	59	135	107
Operating Earnings	**$ 493**	**$ 578**	**$ 131**	**$ 145**	**$ 266**	**$ 146**	**$ (58)**	**$ 21**
Plus: Depreciation, Depletion and Amortization	120	133	121	111	116	129	117	124
Plus: Accretion Expense	13	14	13	15	16	16	16	19
Plus: Foreign Exchange Gain (Loss)	(7)	—	3	(4)	(2)	(2)	4	(1)
Plus: Other Non operating Income (Expense)	—	(24)	1	(9)	—	(1)	(6)	(9)
Plus: Dividends from equity investments	—	—	—	—	25	—	—	—
Less: Earnings (loss) from Consolidated Noncontrolling Interests	4	9	14	5	25	12	8	2
Plus: Notables Items	17	66	226	95	(14)	109	136	107
Adjusted EBITDA[b]	**$ 632**	**$ 758**	**$ 481**	**$ 348**	**$ 382**	**$ 385**	**$ 201**	**$ 259**
Capital expenditures	$ 148	$ 157	$ 168	$ 159	$ 142	$ 119	$ 157	$ 208
Gross Margin $ / tonne of finished product	$ 318	$ 383	$ 217	$ 148	$ 141	$ 112	$ 53	$ 88
Adjusted Gross Margin $ / tonne of finished product	$ 318	$ 383	$ 222	$ 167	$ 141	$ 129	$ 53	$ 106
Gross margin as a percent of sales	*35 %*	*36 %*	*23 %*	*18 %*	*19 %*	*17 %*	*9 %*	*13 %*
Freight included in finished goods (in millions)	$ 90	$ 94	$ 98	$ 95	$ 96	$ 102	$ 92	$ 105
Idle/Turnaround costs (excluding notable items)	$ 31	$ 79	$ 79	$ 70	$ 42	$ 34	$ 25	$ 32
Operating Data								
Sales volumes *('000 tonnes)[d]*								
DAP/MAP	917	814	824	844	1,022	928	913	762
Performance products[f]	659	780	750	640	740	919	673	741
Other products[i]	85	81	77	87	74	75	65	79
Total Finished Product[d]	**1,661**	**1,675**	**1,651**	**1,571**	**1,836**	**1,922**	**1,651**	**1,582**
DAP selling price (fob plant)[r]	$ 785	$ 920	$ 809	$ 722	$ 660	$ 585	$ 487	$ 552
Average finished product selling price (destination)[g]	$ 877	$ 1,048	$ 924	$ 794	$ 717	$ 634	$ 569	$ 658
Production Volumes *('000 tonnes)*								
Total tonnes produced[h]	1,745	1,636	1,664	1,602	1,836	1,660	1,593	1,479
Operating Rate	*70 %*	*66 %*	*67 %*	*65 %*	*74 %*	*67 %*	*64 %*	*60 %*
Raw Materials								
Ammonia used in production (tonnes)	258	236	236	243	274	240	234	209
% manufactured ammonia used in production	*34 %*	*22 %*	*5 %*	*42 %*	*29 %*	*44 %*	*32 %*	*53 %*
Sulfur used in production	818	764	781	745	840	771	735	549
% prilled sulfur used in production	*11 %*	*5 %*	*— %*	*3 %*	*7 %*	*11 %*	*5 %*	*6 %*
Realized costs *($/tonne)*								
Ammonia (tonne)[j]	$ 532	$ 591	$ 665	$ 653	$ 605	$ 441	$ 353	$ 366
Sulfur (long ton)[k]	$ 281	$ 385	$ 436	$ 348	$ 236	$ 195	$ 156	$ 152
Blended rock	$ 61	$ 64	$ 68	$ 78	$ 77	$ 79	$ 81	$ 77
Phosphates cash conversion costs / production tonne[s]	$ 76	$ 86	$ 85	$ 96	$ 96	$ 105	$ 105	$ 118
Cash costs of U.S. mined rock / production tonne[t]	$ 50	$ 46	$ 41	$ 48	$ 58	$ 56	$ 56	$ 56
ARO cash spending (in millions)	$ 33	$ 28	$ 33	$ 43	$ 41	$ 41	$ 42	$ 41

MWSPC equity earnings (loss)	$ 31	$ 34	$ 72	$ 58	$ 31	$ 10	$ 17	$ —
MWSPC total sales tonnes (DAP/MAP/NPK)	592	413	599	684	762	649	771	722
Miski Mayo external sales revenue	$ 26	$ 21	$ 33	$ 38	$ 41	$ 47	$ 33	$ 18

The Mosaic Company - Potash Segment
Selected Calendar Quarter Financial Information
(Unaudited)

	Q1 2022	Q2 2022	Q3 2022	Q4 2022	Q1 2023	Q2 2023	Q3 2023	Q4 2023
Net Sales and Gross Margin *(in millions, except per tonne)*								
Segment income statement								
Net Sales	**$ 1,060**	**$ 1,580**	**$ 1,432**	**$ 1,136**	**$ 907**	**$ 849**	**$ 720**	**$ 758**
Cost of Goods Sold	481	652	633	598	494	513	510	503
Gross Margin	**$ 579**	**$ 928**	**$ 799**	**$ 538**	**$ 413**	**$ 336**	**$ 210**	**$ 255**
Notable Items Included in Gross Margin	—	—	—	—	—	—	—	—
Adjusted Gross Margin[(b)]	**$ 579**	**$ 928**	**$ 799**	**$ 538**	**$ 413**	**$ 336**	**$ 210**	**$ 255**
SG&A	7	8	6	9	8	7	6	8
Other operating (income) expense [(p)]	9	5	—	32	3	1	4	25
Operating Earnings	**$ 563**	**$ 915**	**$ 793**	**$ 497**	**$ 402**	**$ 328**	**$ 200**	**$ 222**
Plus: Depreciation, Depletion and Amortization	77	81	76	73	70	74	66	89
Plus: Accretion Expense	2	2	2	2	2	2	2	3
Plus: Foreign Exchange Gain (Loss)	17	(23)	(19)	6	3	23	(26)	41
Plus: Other Non operating Income (Expense)	—	—	—	—	—	—	(43)	(2)
Plus: Notable Items	(8)	23	19	19	(3)	(19)	68	(31)
Adjusted EBITDA[(b)]	**$ 651**	**$ 998**	**$ 871**	**$ 597**	**$ 474**	**$ 408**	**$ 267**	**$ 322**
Capital expenditures	$ 65	$ 67	$ 78	$ 72	$ 93	$ 74	$ 85	$ 105
Gross Margin $ / tonne of finished product	$ 323	$ 403	$ 373	$ 289	$ 216	$ 155	$ 95	$ 99
Adjusted Gross Margin $ / tonne of finished product	$ 323	$ 403	$ 373	$ 289	$ 216	$ 155	$ 95	$ 99
Gross margin as a percent of sales	*55 %*	*59 %*	*56 %*	*47 %*	*46 %*	*40 %*	*29 %*	*34 %*
Supplemental Cost Information								
Canadian resource taxes	$ 157	$ 274	$ 258	$ 238	$ 121	$ 95	$ 86	$ 102
Royalties	$ 27	$ 32	$ 31	$ 24	$ 19	$ 13	$ 9	$ 13
Freight[(l)]	$ 70	$ 76	$ 55	$ 66	$ 80	$ 94	$ 99	$ 78
Idle/Turnaround costs (excluding notable items)	$ 15	$ 9	$ 13	$ 24	$ 22	$ 35	$ 37	$ 3
Operating Data								
Sales volumes *('000 tonnes)[(d)]*								
MOP	1,532	2,045	1,952	1,707	1,696	1,883	2,031	2,359
Performance products[(m)]	243	245	178	143	201	270	177	207
Other products[(i)]	17	14	12	13	13	10	12	11
Total Finished Product[(d)]	**1,792**	**2,304**	**2,142**	**1,863**	**1,910**	**2,163**	**2,220**	**2,577**
Crop Nutrients North America	618	727	439	594	739	881	1,129	773
Crop Nutrients International	1,020	1,415	1,574	1,145	1,053	1,144	1,007	1,666
Non-Agricultural	154	162	129	125	118	138	84	138
Total Finished Product[(d)]	**1,792**	**2,304**	**2,142**	**1,863**	**1,910**	**2,163**	**2,220**	**2,577**
MOP selling price (fob mine)[(o)]	$ 582	$ 678	$ 666	$ 581	$ 421	$ 326	$ 266	$ 243
Average finished product selling price (destination)[(g)]	$ 591	$ 686	$ 669	$ 610	$ 475	$ 392	$ 324	$ 294
Production Volumes *('000 tonnes)*								
Production Volume	2,200	2,436	2,266	2,151	1,944	1,921	1,854	2,527
Operating Rate	*80 %*	*87 %*	*81 %*	*77 %*	*69 %*	*69 %*	*66 %*	*90 %*
MOP cash costs of production excluding brine / production tonne[(n)]	$ 81	$ 78	$ 78	$ 76	$ 81	$ 74	$ 73	$ 66
ARO cash spending *(in millions)*	$ 18	$ 13	$ 11	$ 5	$ 3	$ 3	$ 3	$ 2

Average CAD / USD	$ 1.267	$ 1.276	$ 1.304	$ 1.358	$ 1.352	$ 1.343	$ 1.342	$ 1.361

The Mosaic Company - Mosaic Fertilizantes Segment
Selected Calendar Quarter Financial Information
(Unaudited)

	Q1 2022	Q2 2022	Q3 2022	Q4 2022	Q1 2023	Q2 2023	Q3 2023	Q4 2023
Net Sales and Gross Margin *(in millions, except per tonne)*								
Segment income statement								
Net Sales	**$ 1,488**	**$ 2,260**	**$ 2,629**	**$ 1,910**	**$ 1,343**	**$ 1,419**	**$ 1,731**	**$ 1,192**
Cost of Goods Sold	1,269	1,810	2,281	1,882	1,344	1,406	1,625	1,098
Gross Margin	**$ 219**	**$ 450**	**$ 348**	**$ 28**	**$ (1)**	**$ 13**	**$ 106**	**$ 94**
Notable Items Included in Gross Margin	(18)	—	14	(1)	—	(13)	(2)	(3)
Adjusted Gross Margin[b]	**$ 237**	**$ 450**	**$ 334**	**$ 29**	**$ (1)**	**$ 26**	**$ 108**	**$ 97**
SG&A	21	27	25	29	26	29	26	29
Other operating (income) expense	11	3	—	19	5	4	3	15
Operating Earnings	**$ 187**	**$ 420**	**$ 323**	**$ (20)**	**$ (32)**	**$ (20)**	**$ 77**	**$ 50**
Plus: Depreciation, Depletion and Amortization	25	27	28	45	32	38	54	41
Plus: Accretion Expense	4	4	4	5	5	5	5	5
Plus: Foreign Exchange Gain (Loss)	119	(83)	(66)	38	23	73	(48)	32
Plus: Other Non operating Income (Expense)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Less: Earnings from Consolidated Noncontrolling Interests	—	(1)	—	—	—	(2)	—	—
Plus: Notable Items	(101)	76	55	(38)	(24)	(31)	60	(16)
Adjusted EBITDA[b]	**$ 233**	**$ 444**	**$ 343**	**$ 29**	**$ 3**	**$ 66**	**$ 147**	**$ 111**
Capital expenditures	$ 75	$ 39	$ 92	$ 100	$ 87	$ 63	$ 118	$ 68
Gross Margin $ / tonne of finished product	$ 120	$ 194	$ 123	$ 11	$ (1)	$ 5	$ 35	$ 44
Adjusted Gross Margin $ / tonne of finished product	$ 130	$ 194	$ 118	$ 12	$ (1)	$ 11	$ 35	$ 45
Gross margin as a percent of sales	*15 %*	*20 %*	*13 %*	*1 %*	*— %*	*1 %*	*6 %*	*8 %*
Idle/Turnaround costs (excluding notable items)	$ 9	$ 30	$ 44	$ 29	$ 11	$ 30	$ 28	$ 26
Operating Data								
Sales volumes *('000 tonnes)*								
Phosphate produced in Brazil	737	638	488	505	510	611	622	492
Potash produced in Brazil	46	46	33	40	44	44	62	45
Purchased nutrients for distribution[q]	1,039	1,636	2,303	1,927	1,526	1,730	2,376	1,621
Total Finished Product	**1,822**	**2,320**	**2,824**	**2,472**	**2,080**	**2,385**	**3,060**	**2,158**
Sales of Performance Products ('000 tonnes)[e]	$ 155	$ 290	$ 574	$ 473	$ 211	$ 283	$ 660	$ 341
Brazil MAP price (Brazil production delivered price to third party)	$ 882	$ 1,021	$ 866	$ 663	$ 669	$ 653	$ 533	$ 580
Average finished product selling price (destination)[g]	$ 817	$ 974	$ 931	$ 773	$ 646	$ 595	$ 566	$ 552
Production Volumes *('000 tonnes)*								
MAP	261	266	174	261	235	219	160	256
TSP	131	129	85	82	106	88	131	50
SSP	312	275	343	332	283	240	321	316
DCP	127	85	114	126	108	133	133	120
NPK	64	55	25	49	45	56	62	32
Total phosphate tonnes produced	**895**	**810**	**741**	**851**	**777**	**736**	**807**	**774**
MOP	94	38	69	100	82	61	106	114
Phosphate operating rate	*92 %*	*83 %*	*76 %*	*87 %*	*78 %*	*74 %*	*81 %*	*77 %*
Potash operating rate	*72 %*	*29 %*	*55 %*	*80 %*	*65 %*	*49 %*	*85 %*	*91 %*
Realized Costs ($/tonne)								
Ammonia/tonne[j]	$ 1,145	$ 1,396	$ 1,267	$ 1,354	$ 1,150	$ 912	$ 667	$ 655

Sulfur (long ton)[k]	$ 337	$ 384	$ 432	$ 402	$ 278	$ 258	$ 219	$ 179
Blended rock	$ 105	$ 102	$ 106	$ 106	$ 124	$ 128	$ 117	$ 117
Purchases *('000 tonnes)*								
DAP/MAP from Mosaic	102	102	30	38	146	117	20	58
MicroEssentials® from Mosaic	248	448	370	205	277	427	152	163
Potash from Mosaic/Canpotex	398	663	798	417	235	756	672	404
Phosphate cash conversion costs in BRL, Production / tonne[s]	R$403	R$506	R$533	R$483	R$538	R$540	R$495	R$546
Potash cash conversion costs in BRL, production / tonne	R$1,296	R$2,285	R$1,591	R$1,176	R$1,455	R$1,701	R$1,143	R$1,064
Mined rock costs in BRL, cash produced / tonne	R$557	R$500	R$525	R$632	R$606	R$533	R$498	R$548
ARO cash spending (in millions)	$ 2	$ 4	$ 5	$ 11	$ 3	$ 4	$ 6	$ 7
Average BRL / USD	$ 5.235	$ 4.917	$ 5.244	$ 5.255	$ 5.196	$ 4.954	$ 4.880	$ 4.953

The Mosaic Company - Corporate and Other Segment
Selected Calendar Quarter Financial Information
(Unaudited)

	Q1 2022	Q2 2022	Q3 2022	Q4 2022	Q1 2023	Q2 2023	Q3 2023	Q4 2023
Net Sales and Gross Margin *(in millions)*								
Segment income statement								
Net Sales	**$ (122)**	**$ (268)**	**$ (290)**	**$ 125**	**$ (28)**	**$ (159)**	**$ 111**	**$ 129**
Cost of Goods Sold	(235)	(95)	(287)	(46)	(27)	(165)	105	57
Gross Margin (Loss)	**$ 113**	**$ (173)**	**$ (3)**	**$ 171**	**$ (1)**	**$ 6**	**$ 6**	**$ 72**
Notable items Included in Gross Margin	100	(62)	(76)	14	(1)	34	(45)	40
Adjusted Gross Margin (Loss)[(b)]	**$ 13**	**$ (111)**	**$ 73**	**$ 157**	**$ —**	**$ (28)**	**$ 51**	**$ 32**
SG&A	97	63	85	80	83	83	78	75
Other operating (income) expense	3	3	5	13	7	8	2	11
Operating Earnings (Loss)	**$ 13**	**$ (239)**	**$ (93)**	**$ 78**	**$ (91)**	**$ (85)**	**$ (74)**	**$ (14)**
Plus: Depreciation, Depletion and Amortization	4	4	4	4	2	3	2	3
Plus: Share-Based Compensation Expense	16	(1)	6	6	12	9	6	6
Plus: Foreign Exchange Gain (Loss)	182	(121)	21	34	27	54	(26)	19
Plus: Other Non operating Income (Expense)	2	(11)	(1)	(53)	(7)	(5)	—	—
Less: Earnings (Loss) from Consolidated Noncontrolling Interests	—	—	—	—	—	—	—	—
Plus: Notable Items	(282)	196	54	8	(25)	(91)	71	(60)
Adjusted EBITDA[(b)]	**$ (65)**	**$ (172)**	**$ (9)**	**$ 77**	**$ (82)**	**$ (115)**	**$ (21)**	**$ (46)**
Elimination of profit in inventory income (loss) included in COGS	$ (76)	$ (180)	$ 104	$ 171	$ 20	$ 35	$ 45	$ 16
Unrealized gain (loss) on derivatives included in COGS	$ 100	$ (59)	$ (76)	$ 14	$ (1)	$ 34	$ (45)	$ 41
Operating Data								
Sales volumes *('000 tonnes)*	370	533	221	466	420	359	482	618
Sales of Performance Products ('000 tonnes)	1	14	9	6	—	—	—	—
Average finished product selling price (destination)[(g)]	$ 597	$ 732	$ 720	$ 692	$ 636	$ 478	$ 423	$ 414
Purchases *('000 tonnes)*								
DAP/MAP from Mosaic	—	—	6	47	—	31	—	—
MicroEssentials® from Mosaic	15	—	15	1	16	3	—	2
Potash from Mosaic/Canpotex	220	471	332	337	296	126	—	345

The Mosaic Company
Selected Calendar Quarter Financial Information
(Unaudited)

Notable Items

Q4 2023

Description	Segment	Line Item	Amount (in millions)	Tax Effect(u) (in millions)	EPS Impact (per basic share)
Foreign currency transaction gain (loss)	Consolidated	Foreign currency transaction gain (loss)	$ 79	$ (16)	$ 0.20
Unrealized gain (loss) on derivatives	Corporate and Other	Cost of goods sold	40	(7)	0.10
Closed and indefinitely idled facility costs	Phosphate	Other operating income (expense)	(9)	2	(0.03)
FX functional currency	Mosaic Fertilizantes	Cost of goods sold	(3)	1	(0.01)
Realized gain (loss) on RCRA Trust Securities	Phosphate	Other non-operating income (expense)	(7)	2	(0.02)
ARO Adjustment	Phosphate	Other operating income (expense)	(4)	1	(0.01)
Environmental reserve	Phosphate	Other operating income (expense)	(64)	11	(0.16)
Land reclamation	Phosphate	Cost of goods sold	(28)	5	(0.07)
ARO adjustment	Potash	Other operating income (expense)	(10)	2	(0.02)
Tax law change	Mosaic Fertilizantes	(Provision for) benefit from income taxes	—	136	0.42
Total Notable Items			**$ (6)**	**$ 137**	**$ 0.40**

Q3 2023

Description	Segment	Line Item	Amount (in millions)	Tax Effect(u) (in millions)	EPS Impact (per basic share)
Foreign currency transaction gain (loss)	Consolidated	Foreign currency transaction gain (loss)	$ (107)	$ 27	$ (0.23)
Unrealized gain (loss) on derivatives	Corporate and Other	Cost of goods sold	(45)	12	(0.10)
Closed and indefinitely idled facility costs	Phosphate	Other operating income (expense)	(12)	3	(0.03)
FX functional currency	Mosaic Fertilizantes	Cost of goods sold	(2)	1	—
Realized gain (loss) on RCRA Trust Securities	Phosphate	Other non-operating income (expense)	(6)	1	(0.01)
ARO Adjustment	Phosphate	Other operating income (expense)	(123)	32	(0.28)
Environmental reserve	Phosphate	Other operating income (expense)	(3)	1	(0.01)
Pension plan termination settlement	Potash	Other non-operating income (expense)	(42)	10	(0.10)
Discrete tax items	Consolidated	(Provision for) benefit from income taxes	—	22	0.07
Total Notable Items			**$ (340)**	**$ 109**	**$ (0.69)**

Q2 2023

Description	Segment	Line Item	Amount (in millions)	Tax Effect[(u)] (in millions)	EPS Impact (per basic share)
Unrealized foreign currency transaction gain (loss)	Consolidated	Foreign currency transaction gain (loss)	$ 114	$ (28)	$ 0.26
Unrealized gain (loss) on derivatives	Corporate and Other	Cost of goods sold	34	(9)	0.08
Closed and indefinitely idled facility costs	Phosphate	Other operating income (expense)	(12)	3	(0.03)
FX functional currency	Mosaic Fertilizantes	Cost of goods sold	(13)	3	(0.03)
Realized gain (loss) on RCRA Trust Securities	Phosphate	Other non-operating income (expense)	2	—	—
ARO Adjustment	Phosphate	Other operating income (expense)	(28)	7	(0.06)
Environmental reserve	Phosphate	Other operating income (expense)	(37)	9	(0.08)
Land reclamation	Phosphate	Cost of goods sold	(31)	8	(0.07)
Total Notable Items			**$ 29**	**$ (7)**	**$ 0.07**

Q1 2023

Description	Segment	Line Item	Amount (in millions)	Tax Effect[(u)] (in millions)	EPS Impact (per basic share)
Foreign currency transaction gain (loss)	Consolidated	Foreign currency transaction gain (loss)	$ 51	$ (12)	$ 0.11
Unrealized gain (loss) on derivatives	Corporate and Other	Cost of goods sold	(1)	—	—
Closed and indefinitely idled facility costs	Phosphate	Other operating income (expense)	(12)	3	(0.03)
Gain on sale of Streamsong Resort	Phosphate	Other operating income (expense)	57	(14)	0.13
FX functional currency	Mosaic Fertilizantes	Cost of goods sold	—	—	—
Realized gain (loss) on RCRA Trust Securities	Phosphate	Other non-operating income (expense)	(8)	2	(0.02)
ARO Adjustment	Phosphate	Other operating income (expense)	(20)	5	(0.04)
Environmental reserve	Phosphate	Other operating income (expense)	(6)	1	(0.01)
Total Notable Items			**$ 61**	**$ (15)**	**$ 0.14**

Q4 2022

Description	**Segment**	**Line Item**	**Amount (in millions)**	**Tax Effect[(u)] (in millions)**	**EPS Impact (per basic share)**
Foreign currency transaction gain (loss)	Consolidated	Foreign currency transaction gain (loss)	$ 75	$ (18)	$ 0.16
Unrealized gain (loss) on derivatives	Corporate and Other	Cost of goods sold	14	(4)	0.03
Closed and indefinitely idled facility costs	Phosphate	Other operating income (expense)	(11)	3	(0.03)
FX functional currency	Mosaic Fertilizantes	Cost of goods sold	(1)	—	—
Fixed asset write-off	Phosphate	Other operating income (expense)	(6)	2	(0.01)
ARO Adjustment	Potash	Other operating income (expense)	3	(1)	0.01
Discrete tax items	Consolidated	(Provision for) benefit from income taxes	—	(9)	(0.03)
Realized gain (loss) on RCRA Trust Securities	Phosphates	Other non-operating income (expense)	(20)	5	(0.04)
Environmental reserve	Phosphates	Other operating income (expense)	(44)	11	(0.09)
Hurricane Ian idle costs	Phosphates	Cost of goods sold	(30)	8	(0.07)
Insurance proceeds	Phosphates	Other operating income (expense)	5	(1)	0.01
Pension plan termination settlement	Consolidated	Other non-operating income (expense)	(42)	10	(0.09)
Environmental reserve	Potash	Other operating income (expense)	(28)	7	(0.06)
Lease termination and severance	Corporate and Other	Other operating income (expense)	(4)	1	(0.01)
Total Notable Items			**$ (89)**	**$ 14**	**$ (0.22)**

Q3 2022

Description	**Segment**	**Line Item**	**Amount (in millions)**	**Tax Effect[(u)] (in millions)**	**EPS Impact (per basic share)**
Foreign currency transaction gain (loss)	Consolidated	Foreign currency transaction gain (loss)	$ (61)	$ 16	$ (0.13)
Unrealized gain (loss) on derivatives	Corporate and Other	Cost of goods sold	(76)	20	(0.16)
Closed and indefinitely idled facility costs	Phosphate	Other operating income (expense)	(12)	4	(0.02)
FX functional currency	Mosaic Fertilizantes	Cost of goods sold	14	(4)	0.03
Discrete tax items	Consolidated	(Provision for) benefit from income taxes	—	(12)	(0.04)
ARO Adjustment	Phosphates	Other operating income (expense)	(143)	36	(0.31)
Environmental reserve	Phosphates	Other operating income (expense)	(71)	18	(0.15)
Hurricane Ian idle costs	Phosphates	Cost of goods sold	(9)	2	(0.02)
Insurance proceeds	Phosphates	Other operating income (expense)	4	(1)	0.01
ARO Adjustment	Mosaic Fertilizantes	Other operating income (expense)	(3)	1	(0.01)
Total Notable Items			**$ (357)**	**$ 80**	**$ (0.80)**

Q2 2022

Description	Segment	Line Item	Amount (in millions)	Tax Effect[u] (in millions)	EPS Impact (per basic share)
Foreign currency transaction gain (loss)	Consolidated	Foreign currency transaction gain (loss)	$ (227)	$ 57	$ (0.47)
Unrealized gain (loss) on derivatives	Corporate and Other	Cost of goods sold	(59)	15	(0.12)
Closed and indefinitely idled facility costs	Phosphate	Other operating income (expense)	(9)	3	(0.03)
Discrete tax items	Consolidated	(Provision for) benefit from income taxes	—	(14)	(0.04)
Realized gain (loss) on RCRA Trust Securities	Phosphates	Other non-operating income (expense)	(26)	7	(0.05)
Gain on sale of plant	Mosaic Fertilizantes	Other operating income (expense)	7	(2)	0.02
ARO Adjustment	Phosphates	Other operating income (expense)	(5)	1	(0.01)
Environmental reserve	Phosphates	Other operating income (expense)	(30)	7	(0.06)
Write down of investment	Corporate and Other	Other non-operating income (expense)	(12)	3	(0.02)
Inventory lower of cost or market	Corporate and Other	Cost of goods sold	(3)	1	(0.01)
Total Notable Items			**$ (364)**	**$ 78**	**$ (0.79)**

Q1 2022

Description	Segment	Line Item	Amount (in millions)	Tax Effect[u] (in millions)	EPS Impact (per basic share)
Foreign currency transaction gain (loss)	Consolidated	Foreign currency transaction gain (loss)	$ 311	$ (78)	$ 0.62
Unrealized gain (loss) on derivatives	Corporate and Other	Cost of goods sold	100	(25)	0.21
Closed and indefinitely idled facility costs	Phosphate	Other operating income (expense)	(9)	3	(0.02)
FX functional currency	Mosaic Fertilizantes	Cost of goods sold	(18)	5	(0.03)
Fixed asset write-off	Phosphate	Other operating income (expense)	(4)	1	(0.01)
ARO Adjustment	Potash	Other operating income (expense)	(9)	2	(0.02)
Discrete tax items	Consolidated	(Provision for) benefit from income taxes	—	9	0.03
Total Notable Items			**$ 371**	**$ (83)**	**$ 0.78**

Footnotes

(a) Notable items impact on Earnings Per Share is calculated as notable item amount plus income tax effect, based on expected annual effective tax rate, divided by diluted weighted average shares. Adjusted Diluted Net Earnings per Share is defined as diluted net earnings (loss) per share excluding the impact of notable items. See "Non-GAAP Reconciliations".
(b) See definitions of Adjusted EBITDA and Adjusted Gross Margin under "Non-GAAP Reconciliations".
(c) Includes elimination of intersegment sales.
(d) Finished product sales volumes include intersegment sales.
(e) Includes MicroEssentials, K-Mag, Aspire and Sus-Terra sales tonnes.
(f) Includes MicroEssentials performance products.
(g) Average price of all finished products sold by Potash, Phosphate, Mosaic Fertilizantes and India/China.
(h) Includes crop nutrient dry concentrates and animal feed ingredients.
(i) Includes finished goods sales of feed and other products.
(j) Amounts are representative of our average ammonia costs in cost of goods sold.
(k) Amounts are representative of our average sulfur costs in cost of goods sold.
(l) Includes inbound freight, outbound freight and warehousing costs on K-Mag, animal feed and domestic MOP sales.
(m) Includes K-Mag, and Aspire finished performance products.
(n) MOP cash costs of production are reflective of actual costs during the period excluding brine management costs, depreciation, depletion, accretion, carbon-based and Canadian resource tax, idle and turnaround costs. Total Production costs for MOP production excludes K-Mag costs, Aspire raw material costs and incremental Aspire operating costs.
(o) Excludes industrial and feed sales. Price has been calculated using the average monthly foreign exchange rate.
(p) Includes sales volumes of phosphate and potash nutrients purchased from other Mosaic segments and Canpotex.
(q) Includes intersegment sales.
(r) Total production costs less depreciation, ARO costs including accretion and idle and turnaround costs divided by metric tonnes of finished phosphate production in the period.
(s) Total production cost less depreciation/depletion, ARO costs including accretion and idle and turnaround costs divided by metric tonnes of rock produced in the period.
(t) Tax impact is based on our expected annual effective rate.

The Mosaic Company
Selected Calendar Quarter Financial Information
(Unaudited)

Non-GAAP Financial Measures

In addition to financial measures prepared in accordance with U.S. generally accepted accounting principles ("GAAP"), Mosaic has presented in this Selected Calendar Quarter Financial Information certain non-GAAP financial measures, or measures calculated based on non-GAAP financial measures, including: Adjusted Diluted Net Earnings Per Share, Consolidated Adjusted EBITDA, Segment Adjusted EBITDA, and Adjusted Gross Margin. Generally, a non-GAAP financial measure is a supplemental numerical measure of a company's performance, financial position or cash flows that either excludes or includes amounts that are not normally excluded or included in the most directly comparable measure calculated and presented in accordance with GAAP. Each of the non-GAAP financial measures we present is determined as described below.

The non-GAAP financial measures we present should not be considered as substitutes for, or superior to, measures of financial performance prepared in accordance with GAAP. In addition, because these non-GAAP measures, as presented, are not determined in accordance with GAAP, they are thus susceptible to varying interpretations and calculations and may not be comparable to other similarly titled measures of other companies.

Adjusted Diluted Net Earnings Per Share

Adjusted diluted net earnings per share is defined as diluted net earnings per share, excluding the impact of notable items. Notable items impact on diluted net earnings per share is calculated as notable item amount plus income tax effect, based on expected annual effective tax rate, divided by diluted weighted average shares. Management believes that adjusted diluted net earnings per share provides securities analysts, investors and others, in addition to management, with useful supplemental information regarding our performance by excluding certain items that may not be indicative of or are unrelated to our core operating results. Management utilizes adjusted diluted net earnings per share in analyzing and assessing Mosaic's overall performance, for financial and operating decision-making, and to forecast and plan for the future periods. Adjusted diluted net earnings per share also assists our management in comparing our and our competitors' operating results. Reconciliations of adjusted diluted net earnings per share to diluted net earnings per share for the periods presented are provided under "Consolidated Data" on the first page of this Selected Calendar Quarter Financial Information.

Consolidated Adjusted EBITDA

Consolidated Adjusted EBITDA is defined as consolidated Net Income (Loss) before net interest expense, depreciation, depletion and amortization, asset retirement obligation accretion, share-based compensation expense and provision for/(benefit) from income taxes. Consolidated Adjusted EBITDA is also adjusted for notable items that management excludes in analyzing our performance. Consolidated Adjusted EBITDA is a non-GAAP financial measure that we provide to assist securities analysts, investors, lenders and others in their comparisons of operational performance, valuation and debt capacity across companies with differing capital, tax and legal structures. Consolidated Adjusted EBITDA should not be considered as an alternative to, or more meaningful than, consolidated Net Income (Loss) as a measure of operating performance. A reconciliation of Consolidated Net Income (Loss) to Consolidated Adjusted EBITDA is provided below.

(*in millions*)	Q1 2022	Q2 2022	Q3 2022	Q4 2022	Q1 2023	Q2 2023	Q3 2023	Q4 2023
Consolidated Net Income (Loss)	$ 1,182	$ 1,036	$ 842	$ 523	$ 435	$ 369	$ (4)	$ 365
Less: Consolidated Interest Expense, Net	(40)	(34)	(31)	(34)	(41)	(36)	(17)	(35)
Plus: Consolidated Depreciation, Depletion & Amortization	226	245	229	233	220	244	239	257
Plus: Accretion Expense	20	20	19	22	23	23	23	27
Plus: Share-Based Compensation Expense	16	(1)	6	6	12	9	6	6
Plus: Consolidated Provision for (Benefit from) Income Taxes	372	369	277	206	118	108	(6)	(44)
Less: Equity in net earnings (loss) of nonconsolidated companies, net of dividends	31	36	72	57	6	13	16	—
Plus: Notable Items not included above	(374)	361	354	84	(66)	(32)	335	—
Consolidated Adjusted EBITDA	$ 1,451	$ 2,028	$ 1,686	$ 1,051	$ 777	$ 744	$ 594	$ 646

Segment Adjusted EBITDA

Adjusted EBITDA presented at the segment level is defined as the related segment's operating earnings (loss) plus depreciation, depletion and amortization plus asset retirement obligation accretion plus foreign exchange gain (loss) plus other income (expense) plus equity earnings (loss) less equity earnings (loss) from noncontrolling interests. Adjusted EBITDA is also

adjusted for notable items that management excludes in analyzing our performance. We provide these non-GAAP financial measures because we believe they are relevant and useful to securities analysts, investors and others because they are part of our internal management reporting and planning process, and our management uses these measures to evaluate the operational performance and valuation of our segments. Management also uses these measures as a method of comparing segment, performance with that of its competitors. Segment Adjusted EBITDA should not be considered as alternatives to, or more meaningful than, segment Operating Earnings (Loss) and segment Operating Earnings (Loss)/sales tonne, respectively, as measures of operating performance. Management believes Operating Earnings (Loss) and segment Operating Earnings (Loss)/sales tonne, respectively, are the most directly comparable GAAP measures because we do not allocate taxes on a segment basis. Reconciliations of Segment Adjusted EBITDA to segment Operating Earnings (Loss) and segment Operating (Loss) Earnings/sales tonne, respectively, are provided as part of each segment's Selected Calendar Quarter Financial Information.

Adjusted Gross Margin

Adjusted gross margin is defined as gross margin excluding the impact of notable items. Management believes the adjusted measures provides security analysts, investors, management & others with useful supplemental information regarding our performance by excluding certain items that may not be indicative of, or are unrelated to, our core operating results. Management utilizes adjusted gross margin in analyzing and assessing Mosaic's overall performance for financial and operating decision-making and to forecast and plan for future periods.

Nutrien®
Feeding the Future™

2022 / Annual Report

About this report:
You can find this report and information on Nutrien on our website at **nutrien.com**. While we include certain non-financial information in this report, more detailed information on our sustainability strategy and performance is provided on our website at **nutrien.com/sustainability**.

The Overview and Letter from our President and CEO contain certain non-IFRS financial measures and other financial measures which do not have a standard meaning under IFRS including:

- Adjusted EBITDA and related guidance
- Adjusted net earnings per share
- Growth Capital
- Return on invested capital ("ROIC")
- Adjusted net debt

For definitions, further information and reconciliation of these measures to the most directly comparable measures under IFRS, see the "Non-IFRS Financial Measures" section. See the "Other Financial Measures" and "Terms & Definitions" sections for definitions, abbreviations and terms used in this annual report.

Living Our Purpose

Nutrien's purpose is **Feeding the Future**, which is rooted in the global challenge of feeding, clothing and fueling a population of 10 billion people by 2050. As the world's largest provider of crop inputs and services, Nutrien plays a leading role in cultivating solutions for growers to meet this challenge and support a new era of sustainable agriculture. By leveraging the competitive advantages of our integrated business model, we are well positioned to efficiently meet the needs of our customers and deliver long-term value for all our stakeholders.

Overview

2022 Year in Review

Advanced strategic initiatives throughout the year

Nutrien advanced several strategic actions that position our company to efficiently meet the needs of our customers, support long-term earnings growth and advancing our key environmental, social and governance ("ESG") priorities.

Delivered record cash from operating activities of

$8.1B

Announced we are evaluating building one of the **world's largest clean ammonia plants** at our existing site in Geismar, LA

Acquired Brazilian Ag retailer **Casa do Adubo S.A.**

Appointed **Ken Seitz** as **President and Chief Executive Officer**

2022

Announced plan to **ramp up annual potash operational capability** to **18Mmt**

Returned
$5.6B
to shareholders
through share repurchases and dividends

Awarded an aggregate of
$500K
to two early-stage companies through our **Radicle Inclusion Challenge**

The recipients are committed to driving **diversity and inclusion** goals while advancing agriculture technologies

$33M invested in our communities with a focus on food security and sustainability.

Overview

2022 Performance Highlights

Delivered record earnings and returned significant cash to our shareholders

In 2022, Nutrien delivered record net earnings due to the strength of agriculture fundamentals, higher fertilizer prices and excellent Nutrien Ag Solutions ("Retail") performance. Our strong cash flow allowed us to invest in the business and return significant cash to our shareholders. We also continued to make progress on our sustainability priorities, including climate and people-related initiatives.

Years ended December 31 (in millions of US dollars, except as otherwise noted)	2022	2021	Change (%)
Financial Performance			
Sales	$ 37,884	$ 27,712	37
Gross Margin	15,424	9,409	64
Net Earnings	7,687	3,179	142
Diluted Net Earnings per Share (US dollars)	14.18	5.52	157
Adjusted Net Earnings per Share [1] (US dollars)	13.19	6.23	112
Adjusted EBITDA [1]	12,170	7,126	71
Retail Adjusted EBITDA	2,293	1,939	18
Potash Adjusted EBITDA	5,769	2,736	111
Nitrogen Adjusted EBITDA	3,931	2,308	70
Phosphate Adjusted EBITDA	594	540	10
Cash Provided by Operating Activities	8,110	3,886	109
Cash Used in Investing Activities	2,901	1,807	61
Growth Capital [1]	1,199	598	101
Cash used for Dividends and Share Repurchase [2]	5,551	2,080	167
Return on Invested Capital ("ROIC") [1]	26%	15%	11
Adjusted Net Debt/Adjusted EBITDA [3]	0.9x	1.4x	(36)
Non-Financial Performance			
CO_2 Equivalent Captured and Sold	1.1Mmt	1.1Mmt	–
Environmental Incidents	35	24	46
Lost-Time Injury Frequency [4]	0.24	0.27	(11)
Total Employees	24,700	23,500	5
Proportion of Women in Senior Leadership (director level and above) [5]	21%	21%	–
Voluntary Employee Turnover Rate [5]	9%	12%	(3)
Community Investment	$ 33	$ 19	74

1 These are non-IFRS financial measures. See the "Non-IFRS Financial Measures" section.
2 This is a supplementary financial measure. See the "Other Financial Measures" section.
3 This is a capital management financial measure that includes a non-IFRS component. See the "Non-IFRS Financial Measures" and "Other Financial Measures" sections.
4 Frequency based on every 200,000 hours worked.
5 Based on regular full-time and part-time employees.

Overview

2030 Sustainability Commitments

Advancing the next wave of agricultural evolution through our Feeding the Future Plan

Nutrien is committed to delivering results for our stakeholders and doing what is right for our planet. Our Feeding the Future Plan sets out a number of ambitious 2030 goals to drive transformation across the agriculture industry and address what we believe are our key ESG risks and opportunities.

Feeding the Planet Sustainably

2030 Commitments	Progress in 2022
Enable growers to adopt sustainable and productive agricultural products and practices on 75 million acres globally.	We continue to provide growers with whole-acre solutions that support sustainable and productive agriculture and aim to deliver improved environmental outcomes. In 2022, we measured and documented approximately 1 million acres in North America and Australia.
Launch and scale a comprehensive Carbon Program, empowering growers and our industry to accelerate climate-smart agriculture and soil carbon sequestration while rewarding growers for their efforts.	In 2022, we enabled North American pilots on approximately 685,000 acres, working with growers and collaborating with approximately 10 suppliers and downstream partners.

Environment and Climate Action

2030 Commitments	Progress in 2022
Achieve at least a 30 percent reduction in greenhouse gas ("GHG") emissions (Scope 1 and 2) per tonne of our products produced, from a baseline year of 2018.	We have continued with multiple initiatives to improve energy efficiency and emissions performance across our manufacturing facilities, including the completion of Nitrous Oxide ("N_2O") abatement projects at Lima, Kennewick and Augusta nitrogen sites.
Invest in new technologies and pursue the transition to low-carbon fertilizers, including low-carbon and clean ammonia.	Announced we are evaluating building one of the world's largest clean ammonia plants in Geismar, LA with a final investment decision expected in the second half of 2023.

Inclusive Agriculture

2030 Commitments	Progress in 2022
Leverage our farm-focused technology partnerships and investments to drive positive impact in industry and grower innovation and inclusion.	Through the Radicle Inclusion Challenge by Nutrien, we invested an aggregate of $500,000 in two startups that are committed to diversity and inclusion, while advancing agriculture technologies.
Create new grower financial solutions to strengthen social, economic and environmental outcomes in agriculture.	Began developing an internal training program for Nutrien Financial employees to help participants better understand financial inclusion and embarked on an external informational campaign aimed at young and new growers to bolster financial literacy.

Overview

Letter from Our President and CEO

Helping feed the world safely and sustainably

The challenge of feeding a growing world has never been more apparent. Each year approximately 70 million people are added to the global population, increasing the need for more food, fiber and fuel. As demand for these life-essentials rises, so do the expectations about how they are produced to ensure we preserve the world's resources for generations to come.

There have been tremendous improvements in agriculture productivity over the past 20 years with global crop yields increasing by more than 30 percent over that period. However, even with these gains, it is estimated that over 10 percent of the world's population is food insecure. Geopolitical conflicts, supply chain issues and extreme weather events have impacted food security across many regions of the world. Addressing this challenge will require a long-term commitment from a broad community of stakeholders that keeps the grower at the center of all solutions.

At Nutrien, our purpose of Feeding the Future speaks to the fundamental role we can play in helping safely and sustainably feed a growing world. It is a purpose that drives us to get better every day and a role that comes with great opportunity and responsibility.

Our Nutrien Ag Solutions business serves approximately 500,000 growers in regions of the world that are being called on to increase crop production. As the largest producer of crop nutrients, we have an unmatched ability to bring on additional low-cost potash and nitrogen production to meet long-term demand.

2022 Shaped by Global Supply Disruptions and Market Volatility

Geopolitical events contributed to an unprecedented level of supply disruption and market volatility across agriculture, energy and fertilizer markets in 2022. Crop supplies were tight entering the year and the onset of the war between Russia and Ukraine placed additional strain on exports of key agriculture commodities. The global grain stocks-to-use ratio declined for the sixth straight year and is now at its lowest level in more than 25 years. Crop prices traded well above historical average levels, supporting grower returns and providing an incentive to increase production.

The impact of supply shocks was even more pronounced on fertilizer markets in 2022. Potash shipments from eastern Europe declined by 11 million tonnes due to the imposition of sanctions on Belarus and financial restrictions on Russia. High natural gas prices in Europe contributed to significant nitrogen capacity curtailments and Russian and Chinese export restrictions caused further disruption to global trade.

Fertilizer prices increased sharply in the first half of 2022 as buyers moved to secure product in an uncertain supply environment. This caused a shift in buying patterns and inventory building in some markets that contributed to an elevated level of market volatility throughout the year.

Delivered Record Earnings and Addressed Key ESG Priorities

Nutrien delivered record adjusted EBITDA [1] of $12.2 billion (net earnings of $7.7 billion) in 2022 and our return on invested capital [1] rose to 26 percent. We took a number of decisive actions in a volatile environment that supported our results and positioned the company for long- term growth and sustainability.

Nutrien Ag Solutions had another very strong year generating adjusted EBITDA of $2.3 billion. We strategically procured crop input products in anticipation of supply chain challenges and increased our proprietary product sales, resulting in higher margins across all major product lines. The growth and relative earnings stability provided by our Retail business is a key advantage that differentiates Nutrien from our fertilizer peers.

Ken Seitz
President and Chief Executive Officer

We made significant progress over the past year on our sustainable agriculture programs in support of the 2030 commitments in our Feeding the Future Plan. We tripled the acres enrolled in our carbon pilot program compared to 2021 and are seeing excellent engagement from growers and strategic partners across the agriculture value chain.

Our Potash results highlighted the importance of low-cost, flexible operations that are backed by a reliable supply chain. In the first half, we sold record offshore volumes in response to increased demand from our customers and achieved higher realized selling prices. We adjusted our production plans in the second half of 2022 as buyers in North America and Brazil limited purchases and drew down inventory. We pulled forward some maintenance activities during this downtime – prioritizing safety in all these actions – and preserved the flexibility

1 These are non-IFRS financial measures. See the "Non-IFRS Financial Measures" section.

> "It is through the advantages of Nutrien's integrated business that we can respond to some of the world's most pressing agriculture challenges while creating significant value for our shareholders."

to quickly ramp up production when demand re-emerges.

We advanced work on our Next Generation Potash initiatives that enhance the safety, reliability and efficiency of our potash mines. Our most significant achievement in 2022 was to remove more employees from the active mining face by achieving over eight thousand employee hours of tele-remote and autonomous mining.

Our Nitrogen and Phosphate businesses benefited from higher global benchmark prices, a diverse product mix and the advantaged cost position of our North American nitrogen plants. We completed emissions abatement projects at three nitrogen sites in 2022 that represent a major step towards meeting our goal to reduce CO_2 equivalent emissions by 1 million tonnes by the end of 2023.

Utilized Strong Cash Flow to Advance Growth Initiatives and Return Capital to Shareholders

Nutrien generated $8.1 billion in cash from operating activities in 2022 and utilized this strong cash flow to advance our capital allocation priorities. We deployed a balanced and disciplined approach with approximately one-third of our operating cash flow invested in projects to sustain our asset base and grow our business, with the remainder returned to shareholders through share repurchases and dividends.

Nutrien Ag Solutions accounted for around 60 percent of the growth capital invested in 2022. We completed 21 Retail acquisitions in our core geographies, with a focus on expanding our network in Brazil. This region is one of the fastest growing agriculture markets that is expected to play an increasingly important role in feeding a growing world.

In Potash, we progressed the ramp up of our existing low-cost potash capacity but have adjusted the timing to optimize capital expenditures in-line with the pace of expected market demand . We will maintain a flexible approach and now expect to reach 18 million tonnes of annual operational capability in 2026. We believe long-term fundamentals support the need for our low-cost, incremental potash capability and there is significant value in having the ability to increase production when the market needs it. We have the advantage of bringing on this capability in increments and at a very low capital cost per tonne.

Our focus in Nitrogen is to enhance our existing network through low-cost brownfield expansions, decarbonization projects and increased production of low-carbon ammonia. The most significant development in 2022 was the announcement that we are evaluating building a 1.2 million tonne clean ammonia plant at our Geismar, Louisiana facility. We are advancing front-end engineering work and anticipate making a final investment decision in the second half of 2023. This project provides an opportunity to leverage existing infrastructure and access to tidewater to participate in current and emerging end-use markets.

We returned approximately $5.6 billion to shareholders through share repurchases and dividends in 2022 and completed our 10 percent share repurchase program in early 2023. We have demonstrated the ability to provide a stable and growing dividend through the cycle and intend on factoring in changes in share count as part of the decision criteria for future per share dividend growth. In February 2023, the Board of Directors approved an increase in the quarterly dividend by 10 percent to $0.53 per share.

Well Positioned for the Future

The fundamentals for our business are strong as agriculture commodity prices remain well above historical levels, global supply contraints persist and demand for crop inputs is expected to increase in 2023. We anticipate that an uncertain global economic and geopolitical environment will continue to impact buyer behaviors, but we do not anticipate the same magnitude of fertilizer market volatility as we witnessed in 2022.

As we look longer-term, we expect structural changes in agriculture, energy and fertilizer markets to support higher crop input pricing levels compared to the past cycle. We believe that our business is well positioned to deliver strong returns to our shareholders as we advance strategic initiatives that grow and fortify our business for the future. We have a unique capability to increase fertilizer sales volumes while leveraging our leading global Retail network to deliver the products, services and solutions that growers need.

Finally, on behalf of our Board of Directors and management team, I would like to thank our nearly 25,000 global employees for their hard work, dedication and focus on safety over the past year. It is through your efforts that we are able to build on the strengths of this integrated platform and position our company to Feed the Future.

Ken Seitz
President and Chief Executive Officer
February 16, 2023

Management's Discussion & Analysis

As at and for the year ended December 31, 2022

The following management's discussion and analysis ("MD&A") is the responsibility of management and is dated as of February 16, 2023. The Board of Directors ("Board") of Nutrien carries out its responsibility for review of this disclosure principally through its Audit Committee, composed entirely of independent directors. The Audit Committee reviews and, prior to its publication, recommends to the Board approval of this disclosure. The Board has approved this disclosure. The term "Nutrien" refers to Nutrien Ltd. and the terms "we", "us", "our", "Nutrien" and "the Company" refer to Nutrien and, as applicable, Nutrien and its direct and indirect subsidiaries on a consolidated basis. This MD&A is based on the Company's audited consolidated financial statements for the year ended December 31, 2022 ("consolidated financial statements") based on International Financial Reporting Standards ("IFRS") as issued by the International Accounting Standards Board, unless otherwise stated.

This MD&A contains certain non-IFRS financial measures and ratios, which do not have a standard meaning under IFRS and, therefore, may not be comparable to similar measures presented by other issuers. Such non-IFRS financial measures and ratios include:

- Adjusted EBITDA
- Adjusted net earnings and adjusted net earnings per share
- Adjusted EBITDA and adjusted net earnings per share guidance
- Growth capital and growth capital allocation
- Gross margin excluding depreciation and amortization per tonne – manufactured
- Potash controllable cash cost of product manufactured per tonne
- Ammonia controllable cash cost of product manufactured per tonne
- Retail adjusted average working capital to sales and Retail adjusted average working capital to sales excluding Nutrien Financial
- Nutrien Financial adjusted net interest margin
- Retail cash operating coverage ratio
- Retail normalized comparable store sales
- Return on invested capital
- Net operating profit after taxes
- Adjusted net debt

For definitions, further information and reconciliation of these measures to the most directly comparable measures under IFRS, see the "Non-IFRS Financial Measures" and "Other Financial Measures" sections.

Also see the cautionary statement in the "Forward-Looking Statements" section.

All references to per share amounts pertain to diluted net earnings (loss) per share. Financial data in this annual report are stated in millions of US dollars, which is the functional currency of Nutrien and the majority of its subsidiaries, unless otherwise noted. Information that is not meaningful is indicated by n/m.

See the "Other Financial Measures" and "Terms & Definitions" sections for definitions, abbreviations and terms used in this annual report including the MD&A.

Additional information relating to Nutrien (which, except as otherwise noted, is not incorporated by reference herein), including our Annual Information Form for the year ended December 31, 2022, can be found on SEDAR at www.sedar.com and on EDGAR at www.sec.gov. The Company is a foreign private issuer under the rules and regulations of the US Securities and Exchange Commission (the "SEC").

The information contained on or accessible from our website or any other website is not incorporated by reference into this MD&A or any other report or document we file with or furnish to applicable Canadian or US securities regulatory authorities.

Our Approach to Annual Reporting

Taking steps toward a more integrated approach to reporting

Nutrien is on a path to a more integrated approach in our annual reporting, with the goal to communicate how we evaluate the opportunities and challenges in our operating environment, which shape our approach to setting strategy, managing risk and governing our actions. The priorities of our key stakeholders impact the way we approach value creation, including addressing key sustainability priorities.

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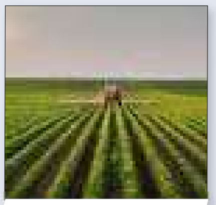
Our Company

Outlines who we are as a company, where we operate, how we create value and describes each of our operating segments



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Our Operating Environment

Defines factors and trends that influence the environment we operate in

22

Our Strategy

Describes our corporate strategy and how each of our segments are supporting that strategy

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Our Governance

Describes our key corporate governance principles and risk identification process

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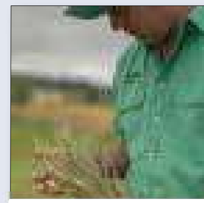
Our Key Enterprise Risks

Outlines the key risks that affect our performance and our future operations



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Our Results and Outlook

Highlights our financial results for the year 2022 and outlook for 2023

About Nutrien

Nutrien is the world's largest provider of crop inputs and services, helping to safely and sustainably feed a growing world. We operate a world-class network of production, distribution and retail facilities that positions us to efficiently serve the needs of growers. We focus on creating long-term value for all stakeholders by advancing our key environmental, social and governance priorities.

Our Company

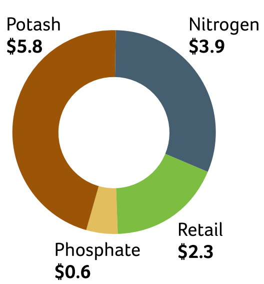
Global Profile

Advantaged position across the agriculture value chain

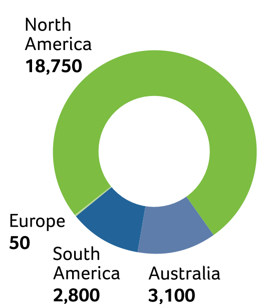
Nutrien has operations and investments in 13 countries, supported by nearly 25,000 talented employees worldwide. We supply products and services to key markets in North America, South America, Asia and Europe.

WHERE OUR EARNINGS COME FROM

Adjusted EBITDA by operating segment in 2022 ($ billions)

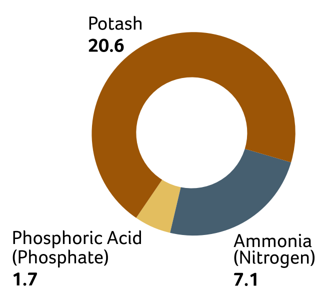


WHERE OUR EMPLOYEES WORK

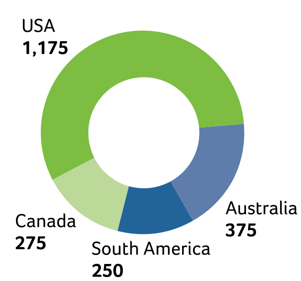


WHAT IS OUR PRODUCTION CAPACITY

Nameplate production capacity (million tonnes of fertilizer N-P-K)



WHERE OUR RETAIL SELLING LOCATIONS ARE SITUATED



Our Company

How We Create Value

Leveraging the advantages of our integrated business model

1 Advantaged Position Across the Ag Value Chain

Our integrated model provides competitive advantages to optimize operations, transportation and logistics, increase supply chain efficiencies and support volume growth.

2 Financial Strength & Stability

Our diversified Retail business enhances the stability of our earnings base and our low-cost fertilizer production assets have historically generated significant cash flow, providing the opportunity to grow our business and return incremental capital to our shareholders.

3 Provider of Sustainable Agriculture Solutions

Positioned to drive long-term value creation through integration of sustainability initiatives, from fertilizer production to grower practices in the field.

Our integrated business model provides a number of advantages compared to our competitors, including operational, financial and sustainability benefits. We continue to explore ways to further enhance the capabilities of our business to capture additional value across the supply chain.

WORLD-CLASS PRODUCTION ASSETS

25Mmt
NPK Manufactured Sales Volumes in 2022

~2,000
Proprietary products

GLOBAL SUPPLY CHAIN

~440
Wholesale fertilizer distribution points

>1,000
Crop input suppliers

LEADING AG RETAIL NETWORK

>2,000
Retail selling locations across North America, South America and Australia

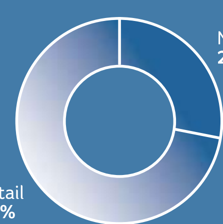
>4,000
Crop consultants

CASH GENERATION

>$21B
in cash provided by operating activities since 2018

GROWTH CAPITAL ALLOCATION

(2018-2022) (percentage)



SHAREHOLDER RETURNS

(2018-2022) (US$ billions)

INNOVATIVE PRODUCTS & SERVICES

Leading provider of
INNOVATIVE
products and services
(Agrible, Waypoint, Echelon)

CARBON PROGRAM

~10
suppliers
and downstream partners in carbon pilot program

LOW-CARBON AMMONIA

1Mmt
of low-carbon annual ammonia production capability

Our Company

Operating Segments

World-class network of production assets, distribution capabilities and premier retailer of crop inputs and services

Nutrien Ag Solutions #1 Global Ag Retailer

Our network of retail selling locations in seven countries provides a wide range of complete agriculture solutions including crop nutrients, crop protection products, seed, application services and digital tools.

We produce and offer approximately 2,000 proprietary crop protection, nutritional, adjuvant and seed treatment products, including a suite of biologicals that complement evolving farming practices. Key brands include Loveland Products and Dyna-Gro seed.

We provide value-added agronomic services from crop plans to soil testing, a leading digital platform that utilizes data driven insights to provide efficient and accurate advice to our customers. We offer attractive working capital solutions for growers through Nutrien Financial and a leading-edge Carbon Program that is connecting farmers to downstream partners in the food value chain.

>2,000 Retail Selling Locations / **~500,000** Grower Accounts / **>4,000** Crop Consultants / **Sustainability, Digital** and **Financial** Solutions

Potash #1 Global Potash Producer

We operate low-cost potash mines in Saskatchewan, which have access to the best potash geology in the world and in a stable geopolitical environment. We employ world-class technologies intended to ensure safer and more responsible mining and have a team with decades of experience in producing potash.

Our six-mine network is diverse and flexible, minimizing supply risk for our customers and limiting the potential for lost sales due to unforeseen production downtime.

We produce granular and standard grade potash, which is primarily shipped by railcars and vessels for delivery to customers in approximately 40 countries around the world. Our extensive transportation and distribution network includes access to four North American marine terminals on both the Atlantic and Pacific coasts.

20.6Mmt Nameplate Potash Capacity / **6** Mines Situated in the Province of Saskatchewan / **~5,900** Owned or Leased Railcars / **285** Distribution Points

Nutrien has four reportable operating segments: Nutrien Ag Solutions ("Retail"), Potash, Nitrogen and Phosphate. The Retail segment distributes crop nutrients, crop protection products, seed and merchandise, and provides services directly to growers through a network of Retail locations in North America, South America and Australia. The Potash, Nitrogen and Phosphate segments are differentiated by the chemical nutrient contained in the products that each produces.

Nitrogen

#3 Global Nitrogen Producer

We produce nitrogen at nine strategically located facilities throughout Canada, the US and Trinidad. Our North American operations, which account for approximately 80 percent of our nitrogen sales volumes, have access to some of the lowest cost natural gas in the world and are in close proximity to key end markets. Our Trinidad operations are situated on tidewater, supporting our sales to over 30 countries, including the European market, and have gas supply contracts indexed to ammonia prices.

Our reliable production network serves a diversified set of agricultural and industrial end markets, with flexibility to optimize product mix and respond to changing market conditions.

We leverage carbon capture, utilization and storage at two of our facilities, and are expanding our low-carbon ammonia production capability. We continue to support our grower customers to reduce their environmental footprint by expanding our portfolio of products with lower environmental impact such as ESN®.

7.1Mmt Nameplate Ammonia Capacity

~5,500 Leased Railcars

190 Distribution Points

1Mmt Low-Carbon Ammonia Production Capability

Phosphate

#2 North American Phosphate Producer

Nutrien has two large integrated phosphate facilities and four regional product upgrade facilities in the US. The high quality of our phosphate rock enables production of a diverse mix of phosphate products, including solid and liquid fertilizers, feed and industrial acids.

This flexibility allows us to optimize our product mix during changing market conditions. We sell the majority of our product in the North American market and benefit from our extensive distribution network and customer relationships. Fertilizer sales historically represent approximately 75 percent of our phosphate sales.

1.7Mmt Nameplate P_2O_5 Capacity

2 Large Integrated Phosphate Mines

4 Upgrade Facilities

Our Operating Environment

We operate in a rapidly changing world. To thrive in these dynamic conditions, we must anticipate and adapt to our environment. As part of Nutrien's strategic and enterprise risk management processes, we seek to understand broader trends and the specific markets where we operate. Understanding our operating environment allows us to better identify risks that could jeopardize our ability to deliver on our strategy and capitalize on emerging opportunities.

Our Operating Environment

Megatrends

Key trends that shape our strategy and actions

We define megatrends as emerging macro-level trends and global dynamics that we believe will have ongoing impacts on business, government and society that shapes our operating environment over the next decade. Tracking and analyzing megatrends informs Nutrien's strategy. See page 22 for more information on our related strategy and page 35 for our related key enterprise risks.

Food Security

Despite advances in modern agriculture, food security remains a global challenge. Producing enough nutritious food for the world's eight billion people, and transporting it to where it is needed, is straining existing global resources. It is estimated that over 10 percent of the world's population is food insecure. A rising population, expected to grow by two billion people in the next 30 years, is further increasing the scale of this challenge.

The agricultural landscape continues to evolve and be influenced by sustainability practices, climate change and social trends that could impact the ability to address global food security challenges. Nutrien is well positioned to develop products and innovative solutions to help our customers feed a growing population while addressing the environmental and social challenges the agriculture industry is facing.

Related Enterprise Risks: Agriculture changes and trends / Climate change / Stakeholder support

Climate Change

Our business, industry, customers and others in the agriculture value chain face long-term challenges from climate change, including increasing expectations for climate actions and reductions of GHG emissions.

Physical risks from a changing climate can impact our operations, our customers and our supply chain. These include more intense weather events, longer droughts, rising sea levels, and changes in average temperature and precipitation patterns. Global decarbonization ambitions and the resulting energy transition are driving carbon regulations and informing capital allocation priorities of investors. Nutrien faces evolving risks related to potential regulatory changes, including carbon pricing.

At the same time, a transition to a low-carbon economy could create significant opportunities for Nutrien to help growers manage these impacts and improve their resilience by facilitating the adoption of climate-smart agriculture practices and developing products that can improve yields in more challenging conditions. The energy transition is accelerating the development of technologies that can support our GHG emission reduction efforts.

Related Enterprise Risks: Climate change

Technology and Digitalization

Digital technologies and access to vast amounts of data are supporting the transformation of our industry and our company. In mining operations, advances in automation and autonomous mining are improving safety by removing workers from the more hazardous areas and enabling productivity increases. Agriculture and food systems are undergoing rapid technological changes driven by big data, digital connectivity, artificial intelligence and innovations in biotechnology. We also have an opportunity to help turn data into insights for our grower customers, and for our grower customers to turn those insights into actions that also presents further opportunities through the agriculture value chain.

The ubiquity of technology and data also creates increased risks to our systems and customer data. Our dependence on technology may contribute to cyber-related events becoming more disruptive and costly and as we gather increasingly more data from our customers, we are continually evolving our practices to align with data privacy regulations.

Related Enterprise Risks: Cybersecurity threats / Agriculture changes and trends

Geopolitical Volatility

Geopolitical turmoil around the world is being driven by nationalism, polarization and economic instability. Due to globalization, regional events are having global impacts. In particular, the Russia and Ukraine war has resulted in, and may continue to result in, supply chain disruptions and higher prices for energy and several commodities, compounding existing energy and food supply chain bottlenecks.

Global geopolitical instability and resulting disruptions could impair our ability to distribute our products in a cost-effective and timely manner to our customers or disrupt our supply chains. If significant geopolitical events occur in one of the countries where we have significant operations, the impact could be more direct and affect our operations, production or revenues. Conversely, disruptions in markets could result in improvements to our financial performance through increased market share or higher sales.

Related Enterprise Risks: Political, economic and social instability

Equality and Societal Expectations

Stakeholders are increasingly focused on corporate sustainability performance and disclosure. Investors are considering environmental and social principles alongside traditional financial metrics in capital allocation decisions and, along with regulators, are increasingly considering the same in evaluating disclosure enhancements. In addition to urgent climate-related matters, societal concerns include impacts on ecosystems and biodiversity, as well as inequality and inequities faced by Indigenous communities, people of colour, LGBTQ+ and disabled individuals inside and outside of the workplace. These societal pressures are reflected in government regulations, investors' priorities and employees' expectations for inclusion practices and for their work to contribute to their sense of personal purpose.

In response to these expectations, governments may impose new regulations or increase the stringency of existing ones. If we are not able to meet our investors' or stakeholders' expectations for environmental and social performance, it could be more difficult to access cost-efficient capital, retain talent or maintain our freedom to operate.

Nutrien believes that our response to these trends can not only help to address some of the world's most pressing challenges but also create opportunities to differentiate ourselves from our competitors. Delivering on our sustainability commitments can attract new investors, support internal engagement, and help attract and retain talent.

Related Enterprise Risks: Changing regulations / Stakeholder support

Our Operating Environment

Market Fundamentals and Competitive Landscape

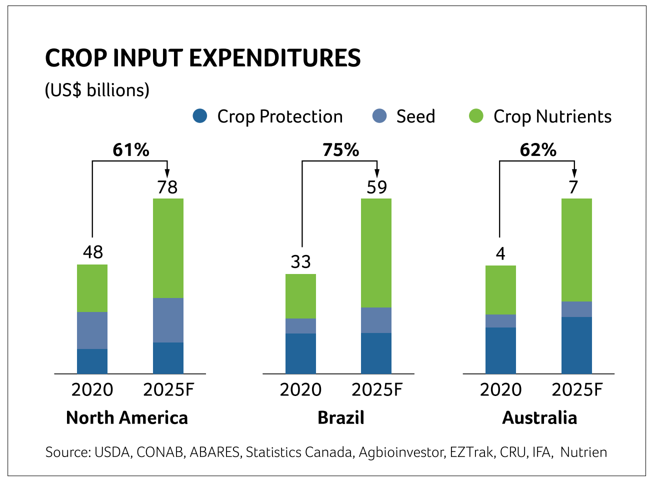
We carefully monitor market fundamentals and our competitive landscape to better position our company for long-term success.

Nutrien Ag Solutions

The agriculture retail industry is highly fragmented in most of the major markets in which we operate, primarily comprised of small and medium-sized competitors. We believe growers are increasingly looking for whole-acre solutions that include a full suite of products, services and solutions. Scale, reliability of supply, and the ability to provide innovative solutions, including digital and sustainability offerings, are increasingly important to growers and their evolving needs.

The US market largely consists of privately owned independent retailers and cooperatives and continues to be a key focus area for growth for Nutrien through tuck-in acquisitions. In Western Canada, Nutrien continues to lead the market and grow organically through our proprietary product offerings, including the Proven seed brand.

The Australian market is unique in that growers require a full suite of crop production inputs but also solutions for livestock, water and irrigation services. Brazil is one of the world's largest and fastest-growing agriculture markets and is currently the largest soybean producer and the third largest producer of corn globally. Compared with other countries, Brazil's agriculture retail industry is significantly fragmented, with more than 14,000 players serving growers in this market.



Brazil is a **significant and growing** crop input market

Market Fundamentals and Competitive Landscape

Potash

Number of Major Producing Countries[1]	20-year Consumption CAGR[2] (2001–2021)	Largest Importers	Largest Exporters
10	**2.8%**	**Brazil, US, China**	**Canada, Russia, Belarus**

1 Countries producing more than 500,000 tonnes annually
2 Compound Annual Growth Rate

High quality potash reserves in significant quantities are limited to a small number of countries globally. Canada has the largest known global potash reserves, accounting for approximately 40 percent of the total. More than 75 percent of the world's potash capacity is held by the six largest producers. Our primary competitors are located in Russia, Belarus, Canada, Germany, Israel and Jordan.

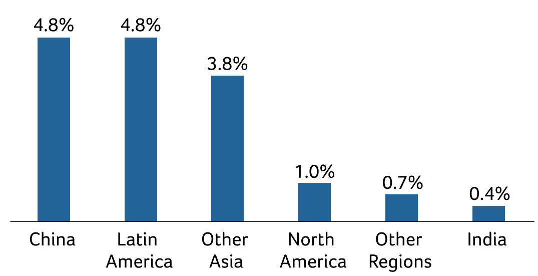
Building new production capacity requires significant capital and time to bring online. Brownfield projects, especially those already completed, have a significant per-tonne capital cost advantage over greenfield projects.

Geological and geopolitical events can result in disruptions to global supply, as was seen in 2022 with sanctions imposed on Belarus and Russia that limited the amount of potash shipments from these countries. In 2022, we estimate that Russian shipments were down approximately 30 percent and Belarussian shipments were down approximately 50 percent from 2021, constraining available supplies and resulting in shifting trade flow patterns.

Most major potash-consuming countries in Asia and Latin America have limited or no production capability and rely on imports to meet their needs. This is an important difference between potash and other major crop nutrients. Trade typically accounts for approximately three-quarters of demand for potash, resulting in a globally diversified marketplace. Most product is sold on a spot basis, while customers in certain countries, such as China and India, purchase under contracts.

Global demand growth for potash has outpaced that of other primary nutrients, with an average annual growth of 2.8 percent between 2001 and 2021. Potash demand growth is driven by increasing nutrient requirements of higher-yielding crops and improving soil fertility practices, particularly in emerging markets where potash has been historically under-applied and crop yields lag.

POTASH DEMAND ANNUAL GROWTH RATE BY REGION
(2001-2021)



Source: CRU, Argus, Fertecon, IFA, Nutrien

Nitrogen

Number of Major Producing Countries [1]	20-year Consumption CAGR [2] (2001–2021)	Largest Importers [3]	Largest Exporters [3]
~40	1.5%	India, Brazil, US	Russia, Qatar, China

1 Countries producing more than 500,000 tonnes annually
2 Compound Annual Growth Rate
3 Ammonia and urea combined

Production of nitrogen is the most geographically diverse of the three primary crop nutrients due to the widespread availability of hydrogen sources. Access to reliable and competitively priced energy feedstock supply is an increasingly important driver of profitability, as recent geopolitical events have created additional volatility in certain global energy markets. North American nitrogen producers currently have an advantaged cost position due to the relatively low price of natural gas compared to competitors in Europe and Asia.

Ammonia is primarily consumed close to the regions in which it is produced due to the cost of transportation, whereas urea and nitrogen solutions are more widely transported and traded. The US remains one of the largest importers of nitrogen and a key driver of global trade despite a significant increase in domestic capacity and production over the past decade. China and India are the largest-consuming countries of nitrogen products, accounting for approximately 40 percent of the worlds consumption.

In developed regions of the world, nitrogen producers are focused on reducing CO_2 emissions. In addition, new markets for low-carbon and clean ammonia are emerging, including marine fuels and as a hydrogen carrier for power generation, with the potential to significantly increase global demand for ammonia.

Phosphate

Number of Major Producing Countries [1]	20-year Consumption CAGR [2] (2001–2021)	Largest Importers [3]	Largest Exporters [3]
~10	1.9%	India, Brazil	China, Morocco

1 Countries producing more than 500,000 tonnes annually
2 Compound Annual Growth Rate
3 DAP and MAP combined

Phosphate rock is found in significant quantity and quality in only a handful of geographic locations. Given the concentration of deposits in North Africa and the Middle East, government involvement is a major consideration when evaluating potential phosphate project developments. Access to low-cost ammonia and sulfur is also an important consideration in producing phosphate.

We compete with producers primarily from China, Morocco, Russia, Saudi Arabia and the US. The majority of new capacity added over the past decade was from producers in China, Morocco, Russia and Saudi Arabia. As a result, total US phosphate production declined by approximately 30 percent over this period.

China's trade policy has a major impact on the global phosphate market. In 2022, Chinese MAP/DAP exports were down approximately 50 percent from 2021 levels as a result of export restrictions. Variability in Chinese operating rates can also impact relevant raw material markets, resulting in volatile sulfur demand and prices. The rate of demand growth for industrial phosphate used in Lithium Iron Phosphate ("LFP") battery manufacturing is expected to grow rapidly over the medium term, and be concentrated in China, which could tighten Chinese phosphate supply.

Our Strategy

Positioning Our Company for Long-Term Growth and Sustainability

Our vision is to be the leading global integrated agriculture solutions provider. In pursuit of our vision, our strategy is to strengthen our business today while investing in strategic initiatives that we believe will grow and fortify our business for the future. We take a balanced and disciplined approach to capital allocation that is focused on delivering superior value through the agriculture cycle, while positioning our company for long-term growth and sustainability.

Nutrien's Strategy

1
Enhancing Margins and Asset Efficiency

Approach
- Driving operational efficiencies and higher utilization rates, along with increasing the reliability of supply to our customers
- Investing in technology and digital tools that support competitive differentiation, operating and cost performance, and best-in-class safety

2
Advancing Strategic Growth Initiatives

Approach
- Expanding our leading production and distribution capabilities in response to structural supply changes and to meet long-term global demand growth
- Focusing on Retail network expansion in large and growing agriculture markets

3
Fortifying Our Business for the Future

Approach
- Reducing GHG emissions and other ESG impacts from our operations
- Focusing on initiatives that enhance on-farm environmental performance
- Investing in our people and procurement programs to foster a culture of inclusion and attract and retain the talent required to deliver on our current and future business needs

Our Strategy

R Nutrien Ag Solutions Focus

Contributing towards a more sustainable agriculture industry

We are growing our world-class Retail network through a combination of organic growth initiatives and accretive acquisitions that enhance our ability to provide whole-acre solutions for growers around the world.

Approach	Key 2022 Activities
1 Enhancing Margins and Asset Efficiency	
• Increase share of higher-margin proprietary products which also boosts yields and enhances soil health. • Strengthen the customer relationship by providing agronomic data and insights. • Invest in digital tools to deliver customer value, drive organic growth through improved customer retention and increased share of wallet.	• **Proprietary products:** Our proprietary products portfolio contributed $1.2 billion of gross margin in 2022, an increase of approximately 60 percent over the past five years. These products generate ~2x higher margins than third-party branded products. • **Agronomic data and insights:** North America Retail digital platform sales [1] increased to $2.8 billion, representing 18 percent of North America Retail sales.
2 Advancing Strategic Growth Initiatives	
• Expand our network by focusing on growth in Brazil and tuck-in acquisitions in the US and Australia.	• **Expand our network:** We completed 21 acquisitions in Brazil, the US and Australia for a total investment of approximately $400 million (net of cash acquired).
3 Fortifying Our Business for the Future	
• Provide solutions that minimize our environmental footprint and enable traceability and emerging carbon markets. • Launch and scale a comprehensive Carbon Program, empowering growers and our industry to accelerate climate-smart agriculture and soil carbon sequestration while rewarding growers for their efforts.	• **Whole-acre solutions:** In 2022, we more than tripled the North America Carbon Pilot Program enabled acres to approximately 685,000 pilot acres and expanded the program in Australia. Through our direct engagement with growers, we have advanced our capabilities to support program expansion and focused on a practical and science-based approach.

Brazil expansion

We continued to expand our presence in Brazil, acquiring a Brazilian company Casa do Adubo S.A., adding 39 retail locations and 10 distribution centers and expanded our footprint in Brazil from 5 states to 13.

1 This is a supplementary financial measure. See the "Other Financial Measures" section.

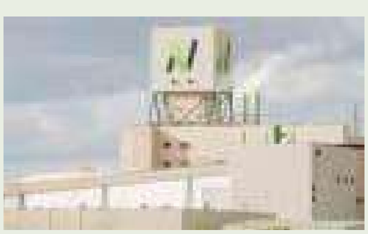
Our Strategy

K Potash Focus

Safely ramping up production to meet global market demand

We are utilizing our world-class network to respond quickly to changes in market supply and demand dynamics. We continue to invest in efficiency and new technologies to lower our costs, optimize and modernize our asset base, advance our sustainability commitments, and preserve the reliability and safety of our operations.

Approach	Key 2022 Activities
1 Enhancing Margins and Asset Efficiency	
• Our Next Generation Potash program is a multi-year investment plan to optimize and modernize potash mining. Our focus is on autonomous mining and predictive maintenance initiatives that enhance safety and strengthen our competitive position by reducing production costs to help offset inflationary pressures.	• **Autonomous mining:** We cut over 6 million ore tonnes in 2022 using automation technologies, an increase of approximately 50 percent from 2021. • **Predictive maintenance:** Our predictive maintenance platform detects and predicts asset failures and monitions critical assets. Our monitoring capacity is rapidly expanding with use of mobile equipment health sensors.
2 Advancing Strategic Growth Initiatives	
• We continuously assess market needs, preserving the ability to flex our mine network and increase production as needed to meet demand. Our six-mine network positions us to bring on significant additional low-cost production that no other existing producer has the capability to deliver.	• **Ramp up production capability:** Announced plans to ramp up to 18 million tonnes of annual operational capability. In 2022, we completed underground mine development, secured additional mining equipment, increased site-based storage and loadout, and hired additional employees.
3 Fortifying Our Business for the Future	
• Explore alternative energy supply initiatives such as the deployment of wind and solar projects, along with partnerships with renewables developers to complement our self-generation at Rocanville, while lowering our environmental footprint. • Progress partnerships with Indigenous communities and a continued focus on spending with our Indigenous suppliers.	• **Exploring renewables:** We advanced the research and planning stages of our renewable energy projects by deploying meteorological and energy resource data collection stations at four additional potash sites, for a total of six stations deployed since 2021. These stations help us better evaluate wind and solar resources at our sites. • **Indigenous procurement:** We exceeded our Indigenous procurement target for our Potash business, reaching approximately 30 percent of eligible local spend with direct Indigenous economic impact.



Potash production capability ramp up

We now intend to safely ramp up our annual operational capability to approximately 18 million tonnes in 2026 at a very low capital cost of $150 to $200 per tonne. We have adjusted the initial timing to optimize capital expenditures in-line with the pace of expected market demand. We have the ability to bring on these volumes in increments, to preserve our flexibility should market fundamentals change.

Our Strategy

N Nitrogen Focus

Advancing the evolution of low-carbon and clean ammonia

We are growing the Nitrogen business through strategic investment projects that improve the reliability and energy efficiency of our facilities while increasing capacity and product flexibility. We are also taking steps to reduce Scope 1 and 2 GHG emissions and are advancing opportunities to further enhance our capability to produce low-carbon ammonia.

Approach	Key 2022 Activities
1 Enhancing Margins and Asset Efficiency	
• Execute on high-return and low-risk debottlenecking projects that enhance reliability, efficiency and productivity.	• **Efficiency and reliability projects:** We completed energy efficiency projects on ammonia plants at our Trinidad and Carseland sites.
2 Advancing Strategic Growth Initiatives	
• Execute on high-return brownfield expansion projects that add incremental volumes while enhancing product flexibility and energy efficiency of our plants.	• **Brownfield expansion projects:** The first phase of projects, completed in 2021, added just under 1 million tonnes of gross production capacity. The second phase of projects is underway and is expected to add approximately 0.5 million tonnes of incremental production capacity through 2025.
3 Fortifying Our Business for the Future	
• Advance our emissions reduction commitments and position for future transformation through projects focused on process improvements, carbon capture, energy efficiency initiatives and renewables evaluation. • Explore new decarbonization technologies. • Pursue projects to manufacture low-carbon fertilizers, including clean ammonia.	• **Low-carbon ammonia:** As of December 31, 2022, Nutrien has annual production capability for approximately 1 million tonnes of low-carbon ammonia across our Geismar, Redwater and Joffre nitrogen facilities. • **Clean ammonia production:** We announced we are evaluating building one of the world's largest clean ammonia plants at our Geismar, LA site. • **Emissions Abatement:** Completed Nitrous Oxide ("N_2O") abatement projects at Lima, Kennewick and Augusta nitrogen sites.

Geismar Clean Ammonia Facility

A final investment decision is expected in the second half of 2023 and, if approved, construction is expected to be completed in 2027. The project is expected to yield 1.2 million tonnes of clean ammonia production annually using auto-thermal reforming technology, with the ability to capture at least 90 percent of CO_2 emissions. The plant would have access to lower-cost, reliable natural gas supply, and tie into Nutrien's expansive transportation and distribution network. This includes direct access to tidewater, to serve existing and new end markets around the world.

Our Strategy

P Phosphate Focus

Optimizing the base business

We remain focused on optimizing our existing phosphate business by lowering our controllable operating costs, increasing plant reliability and further diversifying our product mix.

Approach	Key 2022 Activities
1 Enhancing Margins and Asset Efficiency	
• Optimize product portfolio. • Increase asset utilization rates, operating rates and reliability.	• **Increase asset utilization:** We have various in-flight projects to improve operating rates such as evaporator modifications and increased excavator capacity.
2 Advancing Strategic Growth Initiatives	
• Expand portfolio of industrial and specialty fertilizer products that have historically provided more stable and higher margins. • Explore potential emerging markets such as high-tech markets for high purity phosphoric acid used for lithium iron phosphate ("LFP") battery technology.	• **Enhancing portfolio:** We are expanding our capability to produce industrial and specialty fertilizer products, such as sulfuric acid, ammonium polyphosphate, anhydrous hydrogen fluoride ("AHF") and hydrofluorosilicic acid ("HFSA"). • **Emerging market potential:** Multiple reliability projects within our purified acid plants are underway to address supply shortages and enhance capacity to meet the emerging needs of the market.
3 Fortifying Our Business for the Future	
• Continue focusing on successful land reclamation and tailings pond management.	• **Reclamation projects:** Our Aurora site has permanently protected approximately 3,330 acres of natural uplands and wetlands in the surrounding area to preserve native plant and animal habitat, and our White Springs site planted over 800,000 trees and reclaimed over 2,100 acres between 2020 and 2022.

Our Strategy

Capital Allocation Framework

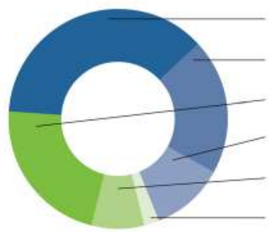
Creating long-term value through balanced and disciplined capital allocation

Nutrien takes a balanced and disciplined approach to capital allocation. Our framework prioritizes maintaining safe and reliable operations, a healthy balance sheet, investing in our business, and providing strong returns to shareholders through a stable and growing dividend and share repurchases.

Priorities		2022	2021
Safe and Reliable Operations	Sustaining Capital Expenditures [1]	$1.4B	$1.2B
Strong Balance Sheet	Adjusted Net Debt/ Adjusted EBITDA [2]	0.9x	1.4x
Return Capital to Shareholders	Cash Used for Dividends and Share Repurchases [1]	$5.6B	$2.1B
High-Return Growth Opportunities	Investing Capital Expenditures [1]	$792M	$510M
	Business Acquisitions [3]	$407M	$88M

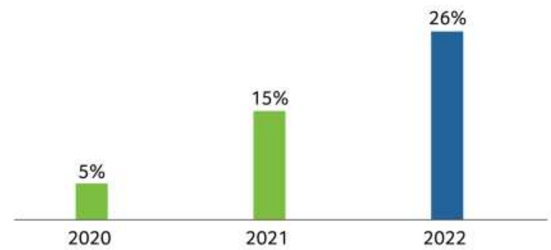
1 These are supplementary financial measures. See the "Other Financial Measures" section.
2 This is a capital management financial measure that includes a non-IFRS component. See the "Non-IFRS Financial Measures" and "Other Financial Measures" sections.
3 Net of cash acquired.

TOTAL CAPITAL ALLOCATION OVER THE LAST 5 YEARS
(% 2018-2022)



Source: Nutrien
1 Mine development and pre-stripping expenditures.

RETURN ON INVESTED CAPITAL ("ROIC")[1]
(%)



Source: Nutrien
1 This is a non-IFRS financial measure. See the "Non-IFRS Financial Measures" section.

Since 2018 allocated **$26B** in a balanced approach

Focused on **strategic initiatives** that enhance ROIC

Approach	Key 2022 Actions
• Our first priority is to sustain our assets to ensure we have safe and reliable operations. • Continuous improvement initiatives and investments that enhance the utilization rates, reliability and efficiency of our assets.	• We replaced identified end-of-life assets at our Potash and Nitrogen sites. • We invested in maintenance for our Retail distribution facilities.
• Provide sufficient and flexible access to liquidity while optimizing the cost of our capital through the cycle. • Expect to maintain adjusted net debt/adjusted EBITDA leverage ratio below 3 times through the cycle.	• We maintained investment-grade credit ratings. • We utilized our liquidity to fund higher working capital requirements due to high market prices and input costs.
• Return capital to shareholders through a combination of stable and growing dividends and share repurchases. • Intend on factoring in reduction in share count in the decision criteria for future per share dividend growth.	• We returned a total of $5.6 billion to shareholders through dividends and by repurchasing approximately 53 million shares. • Average dividend yield of 2.3 percent throughout 2022. In February 2023, we announced a 10 percent increase to our quarterly dividend to $0.53 per share.
• When evaluating investment opportunities, we first consider the strategic fit, then we evaluate the economics of the projects using various financial return metrics. All projects are also evaluated on ESG factors to ensure alignment with our sustainability goals.	• We completed 21 acquisitions in Retail. • We invested in Potash and Nitrogen operational capability growth. • We invested in digital and ESG-related strategies to grow the business and reduce our environmental impact.

Our Governance

Our governance is aligned with Nutrien's purpose and supports risk management for value preservation and long-term value creation through the pursuit of our strategic objectives.

Our Governance

Corporate Governance

Strong corporate governance supports long-term value creation

Nutrien's Corporate Governance Structure includes policies and processes that define the roles of the Board and the Executive Leadership Team ("ELT"). Our Board oversees risk management and the execution of our corporate strategy. Below are a few highlights of our corporate governance practices. For more information, see our most recent Management Information Circular.

Board Diversity

Having a mix of directors on the Board from varied backgrounds and with a diverse range of experience and skills fosters enhanced decision-making capacity and promotes strong corporate governance. Our Board Diversity Policy includes a target that women comprise no fewer than 30 percent of the Board members. As of December 31, 2022, four of our directors are women (33 percent of the total number of directors).

Executive Compensation

Nutrien's compensation framework is based on a pay-for-performance philosophy, with the majority of executive compensation being at risk. Since 2020, a component of executive compensation has been tied to demonstrated ESG performance, including the addition of progress on GHG emission projects and diversity-related metrics in 2021. Each year, we include an advisory "say on pay" vote at our annual meetings (in line with 2019 amendments in the Government of Canada's Bill C-97).

Board Skills

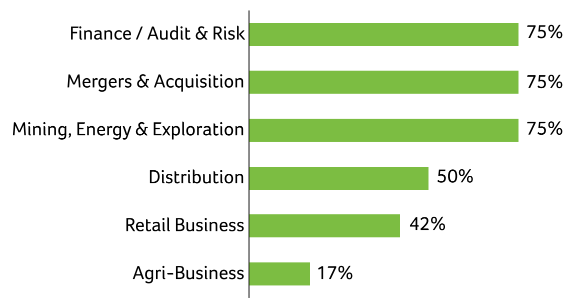
Our Board competencies and skills matrices are essential tools to evaluate whether the Board has the right skills, perspectives, experience and expertise for proper oversight and effective decision-making. The Board regularly reviews the skills matrix.

Our Board orientation and education program helps new directors increase their understanding of their responsibilities and our operations, so that they can be fully engaged and contribute meaningfully to the Board and its committees. Our continuing education program provides regular and ongoing education to advance their knowledge of our business, industry, regulatory environment and other topical areas of interest.

AREAS OF BOARD MEMBERS' SKILLS AND EXPERIENCE

CORE BUSINESS SKILLS [1]
(%)

CORE INDUSTRY EXPERIENCE [1]
(%)



Source: Nutrien

1 As of December 31, 2022.

Our Board of Directors


Russell Girling
Chair


Ken Seitz
President and Chief Executive Officer


Christopher Burley
Director


Maura Clark
Director


Michael Hennigan
Director


Miranda Hubbs
Director


Raj Kushwaha
Director


Alice Laberge
Director


Consuelo Madere
Director


Keith Martell
Director


Aaron Regent
Director


Nelson Luiz Costa Silva
Director

Our Executive Leadership Team


Ken Seitz
President and Chief Executive Officer


Noralee Bradley
Executive Vice President, External Affairs and Chief Sustainability and Legal Officer


Pedro Farah
Executive Vice President and Chief Financial Officer


Andy Kelemen
Executive Vice President and Chief Corporate Development and Strategy Officer


Candace Laing
Senior Vice President, Chief Human Resources Officer


Brent Poohkay
Executive Vice President and Chief Technology Officer


Chris Reynolds
Executive Vice President and President, Potash


Jeff Tarsi
Executive Vice President and President of Global Retail


Mark Thompson
Executive Vice President, Chief Commercial Officer

Our Governance

Risk Governance

Risk management is embedded throughout our organization

Risk management is an integral part of doing business and is governed by our Board, which has the highest level of oversight for risk governance. The Board is responsible for overseeing the execution and alignment of Nutrien's corporate strategy and risk management processes.

Nutrien's ELT has the responsibility of ensuring the Company's principal risks are being appropriately identified, assessed and addressed. Management keeps the Board and each of the Board committees regularly apprised of risks and developments relevant to their mandates.

Responsibility and accountability for risk management are embedded in all levels of our organization, and we strive to integrate risk management into key decision-making processes and strategies. By considering risk throughout our business, we seek to effectively manage the risks that could have an impact on our ability to deliver on our strategy.

Role of the Board Committees

While the Board as a whole oversees our strategy and risk management processes, each Board committee has oversight over business topics and certain risk areas relevant to their committee mandate. More information can be found in Nutrien's Board and Board committee charters on our website at **www.Nutrien.com**.

Board/ Board Committee	Oversight includes the following business topics or risk areas	
Board of Directors	• Corporate strategy • Oversight of safety, health, environmental and security matters	• Risk management • Human resources and compensation • Governance and compliance
Audit Committee	• Accounting and financial reporting • Internal controls	• Compliance • Financial risk management
Corporate Governance & Nominating Committee	• Corporate governance • Board diversity	• Director orientation and continuing education • Board evaluation
Human Resources & Compensation Committee	• Executive compensation • Succession planning	• Equity, diversity and inclusion • Learning and development
Safety & Sustainability ("S&S") Committee	• Sustainability targets and goals • Risks, strengths and opportunities related to safety and sustainability including climate-related impacts	• Safety and sustainability performance & strategy • Cybersecurity and data privacy • Status of remediation projects and environmental provisions

Governance for Climate and Sustainability

The Board's Safety & Sustainability Committee has oversight over Nutrien's climate-related risks and opportunities. The S&S Committee generally meets on a quarterly basis and covers many sustainability-related issues within its mandate including those related to climate. Specifically, the S&S Committee's role includes overseeing: policies relating to sustainability and progress towards sustainability goals; approval of Nutrien's annual ESG Report; reviewing progress against Nutrien's Feeding the Future Plan and associated ESG targets and goals; and review of Nutrien's climate-related risks and opportunities. This committee directly advises the Board on these and other sustainability matters, including safety.

Our Governance

Risk Management Process

Nutrien integrates risk management into our strategy and business activities to facilitate informed risk taking and responsible management of resources

Our annual Enterprise Risk Management process is overseen by our Enterprise Risk Management Team and guided by our global risk management framework. The framework promotes consistent application of risk management principles and processes across our organization and is scalable to support all levels of the business.

All operating segments and corporate functions use this framework to identify, assess and develop mitigation strategies for key risks that could affect their strategy, operations or future performance. Assessment criteria embedded in the risk framework allow for comparability of different types of risks, including climate-related risks. Key criteria include the likelihood of impacting our business and the potential severity of impact.

Risks are evaluated individually and collectively at the management level to fully understand Nutrien's risk landscape and identify interdependencies between risks. A consolidated view of our risks is presented to our ELT and senior leaders for review and discussion, along with outputs from external environment scans and emerging risk workshops. Nutrien's significant enterprise-wide risks are then presented to the Board at least annually.

Our Key Enterprise Risks

Nutrien characterizes a key risk as a risk or combination of risks that could threaten the achievement of our vision, our business model, future financial performance or ability to deliver on our strategy.

Key Enterprise Risks

Identifying and managing risks is critical to achieving our strategic objectives

Our key enterprise risks are discussed below. While these represent our significant risks, we also continue to be exposed to other important general business, operational and climate-related risks. For a more detailed discussion of these key risks and other risks that may affect us, refer to Nutrien's 2022 Annual Information Form.

1 Shifting Market Fundamentals

Description

Changes in global macroeconomic conditions – including trade tariffs and/or other trade restrictions, volatility in global markets, supply chain constraints, increased price competition, or a significant change in agriculture production or consumption trends – could lead to a low crop price environment and reduced demand for our products or increased prices or decreased availability of raw materials used in making our products.

Risk Management Approach

Our global footprint, diversified business model and portfolio of agricultural products, services and solutions are designed to enable us to respond to changing economic conditions. We have a favorable cost-structure and the flexibility to make operational changes across our portfolio in order to minimize the impact of changing market dynamics. We also engage in market development, education, training and customer relations initiatives that support growth.

2 Agriculture Changes and Trends

Description

The following agriculture-related factors, among others, could impact our strategy, demand for our products and/or services and/or financial performance: farm and industry consolidation; shifting grower demographics; agriculture productivity and development; changes in consumer preferences; increasing focus on sustainability in agriculture (including soil health; availability of arable land; diminishing biodiversity; water management); and technological innovation and digital business models.

Risk Management Approach

Our integrated business platform, global footprint, diversified portfolio and strategies are designed to adapt to changes in the agriculture industry and help position us to drive long-term value creation. We are focused on delivering value-added sustainable agriculture solutions for our growers and continued investment in digital tools and technologies.

See page 22 of this report for more information on our strategic initiatives.

3 Climate Change

Description

Climate change may cause or result in, among other things, more frequent and severe weather events, diminishing biodiversity, impacts to growing seasons or crop yields, and changing weather factors such as temperature, precipitation, wind and water levels, and affect fresh water availability. Physical risks from climate change may also result in operational or supply chain disruption, depending on the nature of the event.

Impacts from transition risks could include, but not limited to, policy constraints on emissions, carbon pricing mechanisms, water restrictions, land use restrictions or incentives, changing consumer preferences, and market demand and supply shifts. We are also subject to reputational risks associated with climate change, including our stakeholders' perception of our role in the transition to a lower-carbon economy. These and other factors resulting from climate change could adversely impact our business, financial condition, results of operations or liquidity.

Risk Management Approach

Nutrien is focused on environmental and climate action by advancing sustainable agriculture practices at the farm level and reducing our carbon footprint of our operations. Key focus areas include providing whole-acre solutions to growers, advancing our Carbon Program, exploring renewable energy and pursuing low-carbon fertilizers.

Our capital allocation framework and preventive maintenance programs help support the long-term reliability and efficiency of our assets. Additionally our geographically diversified network of facilities and operations helps to minimize the overall impact of physical risk from climate change on our company.

For more information refer to our most recent ESG Report on our website at **www.Nutrien.com**.

4 Changing Regulations

Description

Changing laws, regulations and government policies including those relating to environmental and climate change, including regulation of GHG emissions, as well as health and safety, taxes and royalties – could affect our ability to produce or sell certain products, reduce our efficiency and competitive advantage, increase our costs of raw materials, energy, transportation and compliance, or require us to make capital improvements to our operations – all of which could impact our strategy, operations, financial performance or reputation.

Risk Management Approach

Our Government & Industry Affairs Team has an active engagement strategy with governments and regulators. This allows us to keep current on regulatory developments affecting our business or industry, allowing us to anticipate new or changing laws and regulations and put us in the best position for success while leveraging our industry association allies.

We have initiatives and commitments supporting environment and climate action, as part of our Feeding the Future Plan, to assist in managing the impact of potential regulatory changes.

5 Cybersecurity Threats

Description

Cyberattacks, ransomware events, and breaches or exposure to potential computer viruses of our systems, third-party service providers' systems or cloud-based platforms could lead to disruptions to our operations, loss of data, or the unintended disclosure of confidential information and/or personally identifiable information or property damage. Any of these could result in business disruptions, reputational damage, personal injury or third-party claims, impacting our operations, financial performance or reputation.

Risk Management Approach

We maintain a heightened focus on cybersecurity and data privacy across our business, which is supported by our cybersecurity strategy, policy and framework.

Nutrien promotes a strong culture of cybersecurity awareness and focuses on minimizing threats and vulnerabilities. Threat and risk assessments are completed for all new information technology systems, and our cybersecurity incident response processes are backstopped by external response measures. We also conduct regular simulated phishing and targeted cybersecurity training.

For more information refer to our most recent ESG Report on our website at **www.Nutrien.com**.

Key Enterprise Risks

6 Political, Economic and Social Instability

Description

Political, economic and social instability may affect our business including, for instance, if any of the jurisdictions in which we operate or do business in introduce restrictions on monetary distributions, forced divestitures or changes to or nullification of existing agreements, mining permits or leases, or the imposition of tariffs, exchange controls, international trade restrictions, embargoes, barriers or other restrictions. Instability in political or regulatory regimes could also affect our ability to do business and could impact our sales and operating results, our reputation, or the value of our assets.

Risk Management Approach

Our Government & Industry Affairs Team has an active engagement strategy with governments, regulators and other stakeholders in the countries where we operate or plan to operate. We assess capital investments and project decisions against political, country and other related risk factors. Dedicated teams regularly monitor developments and global trends that may impact us.

7 Talent and Organization Culture

Description

An inability to attract, develop, engage or retain skilled employees, or establish the right organizational culture or promote and foster a respectful, diverse and inclusive workplace, could impact productivity, reliability, safety performance, costs, customer relationships and/or our reputation.

Risk Management Approach

Our Talent Attraction and Sourcing Team focuses on building a diverse, inclusive and talented workforce. We are committed to the career development of our employees and building a culture grounded in our organizational purpose and the values of safety and integrity. Our talent succession process focuses on identifying and managing critical roles and the proactive build-up of internal and external bench strength with an eye to diversity. Our incentive programs are competitive, performance-based and support our purpose-driven culture.

8 Stakeholder Support

Description

Our stakeholders may not support our business plans, structure, strategy, sustainability initiatives, or climate commitments and social responsibilities. Our inability to meet our sustainability and climate-related commitments and targets may also have an adverse effect on our stakeholder support, among others. Loss of stakeholder confidence could impair our ability to execute our business plans, negatively impact our ability to produce or sell our products, and may lead to reputational damage, increased costs, financial losses, shareholder action or negatively impact our access to or cost of capital.

Risk Management Approach

Our Issues Management Team monitors stakeholder issues and regularly engages with them to identify and address their concerns and communicate the long-term value opportunities associated with our business. We also have an active Community Relations Team and community investment programs. Our Feeding the Future Plan is structured to help support what matters most to our stakeholders.

See page 5 of this report for more information on our 2030 sustainability commitments.

9 Supply Chains

Description

Supply chain disruptions could result in difficulties supplying materials to our facilities and/or impair our ability to deliver products to our customers in a timely manner. If certain key raw materials, parts and/or supplies used in our operations are not available, our business could be disrupted. Ongoing geopolitical conflicts, including the war between Russia and Ukraine, and/or the COVID-19 pandemic could still create supply chain challenges and disruptions, and/or limit our ability to timely sell or distribute our products in the future, any of which could negatively impact our business, financial condition and operating results.

Risk Management Approach

Our integrated model provides us the flexibility to optimize operations, transportation and logistics, or increase supply chain efficiencies to adapt to potential disruption. We regularly review our suppliers to ensure we can maintain critical feedstocks and can leverage our diverse retail distribution network and expansive fertilizer terminal and transportation network to effectively manage product logistic challenges.

10 Capital Redeployment

Description

Our inability to deploy capital to efficiently achieve sustained growth, effectively execute on opportunities or meet investor preferences – whether due to market conditions, lack of options or otherwise, or deploying capital in a manner inconsistent with our strategic priorities – could impact our returns, operations, reputation or access to or cost of capital.

Risk Management Approach

We are focused on creating long-term value through a balanced and disciplined approach to capital allocation. We prioritize maintaining safe and reliable operations, a healthy balance sheet, investing in our business and providing strong returns to shareholders.

See page 29 of this report for more information on our capital allocation priorities and key actions during the year.

11 Safety, Health and Environment

Description

Our operations are subject to safety, health and environmental risks inherent in mining, manufacturing, transportation, storage and distribution of our products. These factors could result in injuries or fatalities, or impact air quality, biodiversity, water resources or related ecosystems near our operations, impacting our operations, financial performance or reputation.

Risk Management Approach

Our safety strategy and robust governance processes ensure we follow all regulatory, industry and internal standards of safety, health and environmental responsibility that involve independent audits and assessments. We have structured incident prevention and response systems in place and conduct regular security vulnerability assessments. We have crisis communication protocols and emergency response programs across our business and maintain environmental monitoring and control systems, including third-party reviews of key containment structures.

Refer to our website at **www.Nutrien.com** for more information on our safety strategy.

Our Results and Outlook

We report our results in four reportable operating segments: Nutrien Ag Solutions ("Retail"), Potash, Nitrogen and Phosphate.

- Adjusted EBITDA is the primary profit measure used to evaluate the segments' performance as it excludes the impact of non-cash impairments and impairment reversals and other costs that are centrally managed by our corporate function. Refer to Note 3 to the consolidated financial statements for details.
- Net sales (sales less freight, transportation and distribution expenses) is the primary revenue measure used in planning and forecasting in the Potash, Nitrogen and Phosphate operating segments.

Our Results and Outlook

2022 Nutrien Ag Solutions ("Retail") Financial Performance

Our Retail business delivered record adjusted EBITDA of $2.3 billion driven by higher sales and gross margins across nearly all product categories and regions where we operate. This was supported by strong agriculture fundamentals, higher selling prices and growth in proprietary product margins. We improved our cash operating coverage ratio[1] to 55 percent compared to the prior year as a result of strong margins. Our proprietary products portfolio contributed 24 percent of total Retail gross margin, and Retail digital platform sales[2] increased to $2.8 billion, representing 18 percent of Retail digital platform sales to total sales[2] in North America. Nutrien Financial generated growth in US finance offerings and program adoption and continued its expansion into Australia.

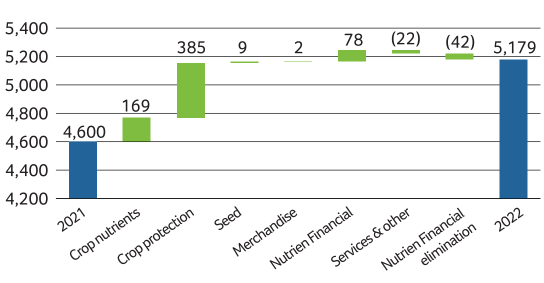
Acquisitions continue to be a significant part of our growth strategy. We completed 21 acquisitions in the US, Brazil and Australia in 2022 and were more selective given the stage of the agricultural cycle.

1 These are non-IFRS financial measures. See the "Non-IFRS Financial Measures" section.
2 These are supplementary financial measures. See the "Other Financial Measures" section.

	Dollars			Gross Margin			Gross Margin (%)	
(millions of US dollars, except as otherwise noted)	**2022**	2021	% Change	**2022**	2021	% Change	**2022**	2021
Sales								
Crop nutrients	**10,060**	7,290	38	**1,766**	1,597	11	**18**	22
Crop protection products	**7,067**	6,333	12	**1,936**	1,551	25	**27**	24
Seed	**2,112**	2,008	5	**428**	419	2	**20**	21
Merchandise	**1,019**	1,033	(1)	**174**	172	1	**17**	17
Nutrien Financial	**267**	189	41	**267**	189	41	**100**	100
Services and other [1]	**966**	980	(1)	**749**	771	(3)	**78**	79
Nutrien Financial elimination [1, 2]	**(141)**	(99)	42	**(141)**	(99)	42	**100**	100
	21,350	17,734	20	**5,179**	4,600	13	**24**	26
Cost of goods sold	**16,171**	13,134	23					
Gross margin	**5,179**	4,600	13					
Expenses [3]	**3,621**	3,378	7					
Earnings before finance costs and taxes ("EBIT")	**1,558**	1,222	27					
Depreciation and amortization	**752**	706	7					
EBITDA	**2,310**	1,928	20					
Adjustments [4]	**(17)**	11	n/m					
Adjusted EBITDA	**2,293**	1,939	18					

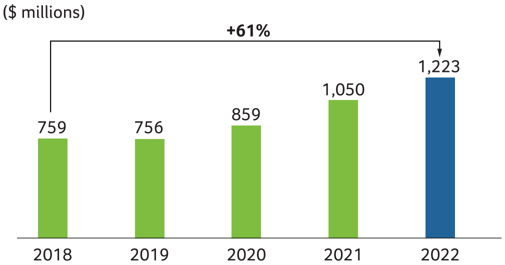
1 Certain immaterial figures have been reclassified for the twelve months ended December 31, 2022.
2 Represents elimination for the interest and service fees charged by Nutrien Financial to Retail branches.
3 Includes selling expenses of $3,392 million (2021 – $3,124 million).
4 See Note 3 to the consolidated financial statements.

RETAIL GROSS MARGIN CHANGES BY PRODUCT
($ millions)



Source: Nutrien

PROPRIETARY GROSS MARGIN
($ millions)



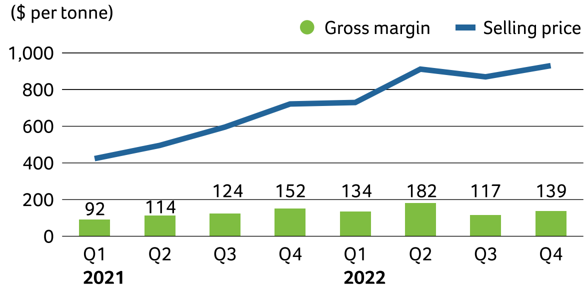
Source: Nutrien

The most significant contributors to the changes in our Retail financial performance were as follows:

	2022 vs 2021
Crop nutrients	Sales increased in 2022 due to higher selling prices. Gross margin increased in 2022, due to strategic procurement and the timing of inventory purchasing earlier in 2022. Sales volumes decreased in 2022 due to reduced application resulting from a delayed North American planting season and stronger fourth quarter engagement in 2021 due to a rising price environment.
Crop protection products	Sales and gross margin increased in 2022, particularly in North America, due to higher selling prices along with increased sales and gross margin in proprietary products. Gross margin percentage increased in 2022, supported by the reliability of our supply chain and strategic procurement in a rising price environment.
Seed	Sales and gross margin increased in 2022 due to higher pricing along with higher sales of corn in North America, soybean in South America and canola in Australia. Gross margin increased due to higher selling prices.
Merchandise	Gross margin increased in 2022 due to strong margin performance in Australia animal management, farm services and general merchandise partially offset by unfavorable foreign exchange rate impact on Australian dollars.
Nutrien Financial	Sales increased in 2022 due to higher utilization and adoption of our programs and a higher interest-bearing trade receivable balance, driven by strong commodity pricing.
Services and other	Sales and gross margin decreased in 2022 mainly due to lower livestock volumes in Australia, along with an unfavorable foreign exchange rate impact on Australian dollars.
Selling expenses	Expenses increased in 2022 due to higher sales activity, competitive pressure on wages and inflationary impacts.
Adjusted EBITDA	Adjusted EBITDA increased in 2022 due to higher sales and gross margins across nearly all product categories and regions where we operate. This was supported by strong agriculture fundamentals, higher selling prices and growth in proprietary products margins. Selling expenses as a percentage of sales improved compared to 2021.

RETAIL CROP NUTRIENT GROSS MARGIN & SELLING PRICE

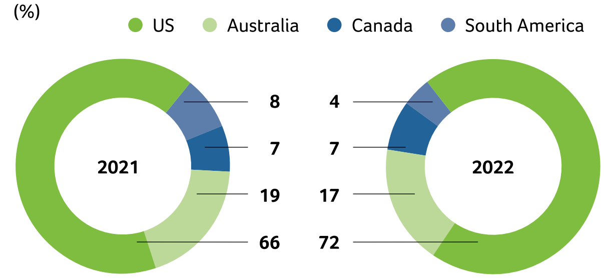
($ per tonne)



Source: Nutrien

CONTRIBUTION TO ADJUSTED EBITDA BY MARKET

(%)



Source: Nutrien

Selected Retail Measures

	2022	2021
Proprietary products gross margin (millions of US dollars)		
Crop nutrients	370	328
Crop protection products	675	527
Seed	166	183
Merchandise	12	12
All products	1,223	1,050
Proprietary products margin as a percentage of product line margin (%)		
Crop nutrients	21	21
Crop protection products	35	34
Seed	39	44
Merchandise	7	7
All products	24	23

	2022	2021
Crop nutrients sales volumes (tonnes – thousands)		
North America	8,106	9,848
International	3,407	3,535
Total	11,513	13,383
Crop nutrients selling price per tonne		
North America	916	556
International	774	512
Total	874	545
Crop nutrients gross margin per tonne		
North America	182	133
International	86	82
Total	153	119

Financial performance measures	2023 Target	2022 Actuals	2021 Actuals
Retail adjusted EBITDA margin (%) [1]	11	11	11
Retail adjusted EBITDA per US selling location (thousands of US dollars) [1,2]	1,100	1,923	1,481
Retail adjusted average working capital to sales (%) [3]	17	17	13
Retail adjusted average working capital to sales excluding Nutrien Financial (%) [3]	n/a	2	–
Nutrien Financial adjusted net interest margin (%) [3]	n/a	6.8	6.6
Retail cash operating coverage ratio (%) [3]	60	55	58
Retail normalized comparable store sales (%) [3]	n/a	(4)	7
Retail digital platform sales to total sales (%) [1,4]	50	18	17

1 These are supplementary financial measures. See the "Other Financial Measures" section.
2 Excluding acquisitions.
3 These are non-IFRS financial measures. See the "Non-IFRS Financial Measures" section.
4 Grower and employee Retail sales in North America entered directly into the digital platform as a percentage of total Retail sales in North America.

Nutrien Financial

We offer flexible financing solutions to our customers in support of Nutrien's agricultural product and service sales. Qualifying Retail customers in the US and Australia are offered extended payment terms, typically up to one year, to facilitate the alignment of grower crop cycles with cash flows. Nutrien Financial revenues are primarily earned through interest and service fees that are charged to our Retail branches.

We hold a significant portion of receivables from customers that have historically experienced a low-default rate. We manage our credit portfolio based on a combination of review of customer credit metrics, past experience with the customer and exposure to any single customer. Nutrien Financial, which is our wholly-owned finance captive, monitors and services the portfolio of our high-quality receivables from customers that have the lowest risk of default among Retail's receivables from customers. We monitor the results of this portfolio of receivables separately because we calculate the cost of capital attributable to the high-quality receivables from customers differently from our other receivables. Specifically, we assume a debt to equity ratio of 7:1 in funding Nutrien Financial receivables, based on the underlying credit quality of the assets.

Nutrien Financial relies on corporate capital for funding. We estimate the deemed interest expense using an average borrowing rate of 1.4 percent applied to the notional debt required to fund the portfolio of receivables from customers monitored and serviced by Nutrien Financial. The balance of our Retail receivables (outside of Nutrien Financial) are subject to marginally higher credit risk.

(millions of US dollars)	Current	<31 Days Past Due	31–90 Days Past Due	>90 Days Past Due	Gross Receivables	Allowance [1]	As at December 31, 2022 Net Receivables	2021 Net Receivables
North America	1,658	225	75	78	2,036	(29)	2,007	1,488
International	574	53	14	28	669	(7)	662	662
Nutrien Financial receivables [2]	2,232	278	89	106	2,705	(36)	2,669	2,150

1 Bad debt expense on the above receivables for the twelve months ended December 31, 2022 was $10 million (2021 – $10 million) in the Retail segment.
2 Gross receivables include $2,260 million (2021 – $1,792 million) of very low risk of default and $445 million (2021 – $386 million) of low risk of default.

Our Results and Outlook

2022 Potash Financial Performance

Our Potash business delivered record adjusted EBITDA of $5.8 billion as higher realized prices and strong offshore volumes more than offset lower North American sales volumes, higher cash cost of goods sold per tonne and higher provincial mining taxes. Potash supply constraints from Russia and Belarus during 2022 resulted in higher prices in both spot and contract markets. Potash demand in North America and Brazil declined in the second half of 2022 as buyers worked through inventory that was built early in the year. These regions represent the two largest markets for Nutrien's potash, therefore the decline in demand and prices in the second half of 2022 had a more significant near-term impact on our business.

We adjusted our production plans in the second half of 2022 in response to lower market demand and pulled forward some maintenance activities.

	Dollars			Tonnes (thousands)			Average per Tonne		
(millions of US dollars, except as otherwise noted)	**2022**	2021	% Change	**2022**	2021	% Change	**2022**	2021	% Change
Manufactured product									
Net sales									
North America	**2,485**	1,638	52	**3,729**	5,159	(28)	**667**	317	110
Offshore	**5,414**	2,398	126	**8,808**	8,466	4	**615**	283	117
	7,899	4,036	96	**12,537**	13,625	(8)	**630**	296	113
Cost of goods sold	**1,400**	1,285	9				**112**	94	19
Gross margin – total	**6,499**	2,751	136				**518**	202	156
Expenses [1]	**1,173**	512	129	**Depreciation and amortization**			**35**	36	(1)
EBIT	**5,326**	2,239	138	**Gross margin excluding depreciation and amortization – manufactured** [3]			**553**	238	133
Depreciation and amortization	**443**	488	(9)						
EBITDA	**5,769**	2,727	112	**Potash controllable cash cost of product manufactured** [3]			**58**	52	12
Adjustments [2]	**–**	9	(100)						
Adjusted EBITDA	**5,769**	2,736	111						

1 Includes provincial mining taxes of $1,149 million (2021 – $466 million).
2 See Note 3 to the consolidated financial statements.
3 These are non-IFRS financial measures. See the "Non-IFRS Financial Measures" section.

The most significant contributors to the changes in our Potash financial performance were as follows:

	2022 vs 2021
Sales volumes	North America sales volumes decreased in 2022 due to a compressed spring application season that resulted in high inventory carryover along with cautious purchasing in key markets caused by a declining price environment during the second half of the year. Offshore sales volumes were the highest of any full year on record due to reduced supply from Eastern Europe.
Net realized selling price	Average net realized selling prices increased in 2022 due to the impact of reduced supply, in particular related to uncertainty on future supply from Eastern Europe due to the imposition of sanctions on Belarus and financial restrictions on Russia.
Cost of goods sold per tonne	Costs increased in 2022 primarily due to higher royalties resulting from increased net realized selling prices. Potash controllable cash cost of product manufactured per tonne increased mainly due to lower production volumes and higher maintenance activities in the second half of 2022.
Expenses	Expenses increased in 2022 primarily due to higher provincial mining taxes from higher average potash selling prices, which are the basis for certain taxes. We are subject to Saskatchewan provincial resource taxes, including the potash production tax and the resource surcharge.
Adjusted EBITDA	Adjusted EBITDA increased in 2022 due to higher net realized selling prices and strong offshore sales volumes, which more than offset lower North American sales volumes, higher cost of goods sold and higher provincial mining taxes.

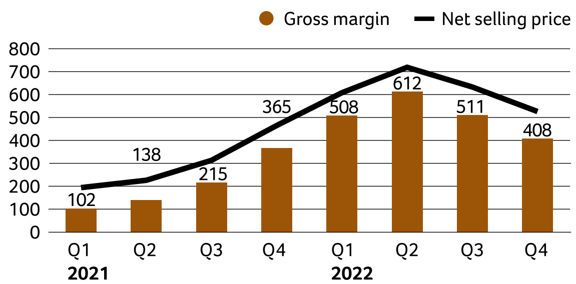
Canpotex Sales by Market

(percentage of sales volumes, except as otherwise noted)	2022	2021	Change
Latin America	34	38	(4)
Other Asian markets [1]	34	35	(1)
China	14	11	3
Other markets	10	10	–
India	8	6	2

1 All Asian markets except China and India.

POTASH GROSS MARGIN AND NET SELLING PRICE

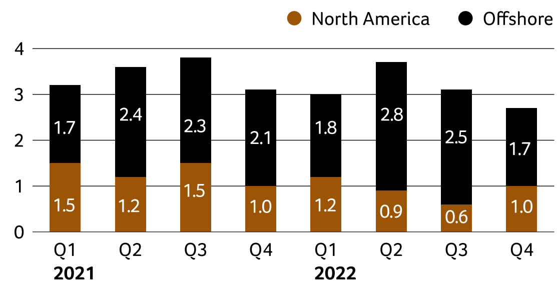
($ per tonne)



Source: Nutrien

POTASH SALES VOLUMES

(million tonnes)



Source: Nutrien

Potash Production

(million tonnes KCl)	Nameplate Capacity [1]	Operational Capability [2] 2023	Operational Capability [2] 2022	Production 2022	Production 2021
Rocanville Potash	6.5	5.2	5.2	4.89	5.00
Allan Potash	4.0	3.0	2.9	2.50	2.78
Vanscoy Potash	3.0	1.4	1.3	1.01	1.05
Lanigan Potash	3.8	3.1	2.8	2.46	2.91
Cory Potash	3.0	2.2	2.1	1.89	1.77
Patience Lake Potash	0.3	0.3	0.3	0.26	0.28
Total	20.6	15.2	14.6	13.01	13.79
Shutdown weeks [3]				18	14

1 Represents estimates of capacity as at December 31, 2022. Estimates based on capacity as per design specifications or Canpotex entitlements once determined. In the case of Patience Lake, estimate reflects current operational capability. Estimates for all other facilities do not necessarily represent operational capability.
2 Estimated annual achievable production level at current staffing and operational readiness (2023 was estimated at the beginning of the year, and may vary during the year, and year-to-year, including between our facilities). Estimate does not include inventory-related shutdowns and unplanned downtime. In 2022, we increased capability by 0.3 million tonnes as part of our announced operational capability ramp-up plan.
3 Represents weeks of full production shutdown, excluding the impact of any periods of reduced operating rates and planned routine annual maintenance shutdowns and announced workforce reductions.

Our Results and Outlook

2022 Nitrogen Financial Performance

Nutrien delivered record Nitrogen adjusted EBITDA of $3.9 billion primarily due to higher net realized prices and higher earnings from equity-accounted investees, which more than offset higher natural gas costs and lower sales volumes.

Nitrogen benchmark prices strengthened in 2022 due to higher energy prices in key nitrogen producing regions and global supply constraints. Record high European natural gas prices led to reduced nitrogen operating rates in Europe, particularly in the second half of the year. Russian ammonia exports were approximately one quarter of pre-conflict levels and Chinese urea exports were down approximately 50 percent year-over-year driven by export restrictions. Gas curtailments in Trinidad, unplanned plant outages and a compressed North America spring application season resulted in lower volumes sold. Cost of production increased due to higher natural gas, raw material and other input costs.

	Dollars			Tonnes (thousands)			Average per Tonne		
(millions of US dollars, except as otherwise noted)	**2022**	2021	% Change	**2022**	2021	% Change	**2022**	2021	% Change
Manufactured product									
Net sales									
Ammonia	**2,641**	1,393	90	**2,715**	2,919	(7)	**973**	477	104
Urea	**1,920**	1,463	31	**2,757**	3,059	(10)	**696**	478	46
Solutions, nitrates and sulfates	**1,829**	1,128	62	**4,551**	4,747	(4)	**402**	238	69
	6,390	3,984	60	**10,023**	10,725	(7)	**638**	371	72
Cost of goods sold	**3,197**	2,353	36				**319**	219	46
Gross margin – manufactured	**3,193**	1,631	96				**319**	152	110
Gross margin – other [1]	**88**	95	(7)	**Depreciation and amortization**			**56**	52	7
Gross margin – total	**3,281**	1,726	90						
(Income) expenses [2]	**(92)**	(3)	n/m	**Gross margin excluding depreciation and amortization – manufactured** [4]			**375**	204	84
EBIT	**3,373**	1,729	95						
Depreciation and amortization	**558**	557	–	**Ammonia controllable cash cost of product manufactured** [4]			**59**	50	18
EBITDA	**3,931**	2,286	72						
Adjustments [3]	**–**	22	(100)						
Adjusted EBITDA	**3,931**	2,308	70						

1 Includes other nitrogen (including ESN® and Rainbow) and purchased products and comprises net sales of $1,143 million (2021 – $705 million) less cost of goods sold of $1,055 million (2021 – $610 million).
2 Includes earnings from equity-accounted investees of $233 million (2021 – $76 million).
3 See Note 3 to the consolidated financial statements.
4 These are non-IFRS financial measures. See the "Non-IFRS Financial Measures" section.

The most significant contributors to the changes in our Nitrogen financial performance were as follows:

	2022 vs 2021
Sales volumes	Sales volumes for ammonia and urea decreased in 2022 mainly due to Trinidad natural gas curtailments, unplanned plant outages and a compressed North American spring application season.
Net realized selling price	Average net realized selling prices increased in 2022 due to higher benchmark prices resulting from tight global supply and higher energy prices in key nitrogen producing regions.
Cost of goods sold per tonne	Costs increased in 2022 primarily due to higher natural gas costs. Raw materials and other input costs were also higher in 2022 compared to 2021. Ammonia controllable cash cost of product manufactured per tonne increased due to lower production and higher input costs (mainly electricity).
(Income) expenses	Other income increased in 2022 mainly due to higher earnings from our equity-accounted investment in Profertil. Profertil's earnings were higher mainly due to higher urea net selling prices from higher benchmark prices.
Adjusted EBITDA	Adjusted EBITDA increased in 2022 primarily due to higher net realized selling prices and higher earnings from equity-accounted investees, which more than offset higher cash cost of goods sold per tonne and lower sales volumes.

Natural Gas Prices in Cost of Production

(US dollars per MMBtu, except as otherwise noted)	2022	2021	% Change
Overall gas cost excluding realized derivative impact	7.82	4.60	70
Realized derivative impact	(0.05)	0.01	n/m
Overall gas cost	7.77	4.61	69
Average NYMEX	6.64	3.84	73
Average AECO	4.28	2.84	51

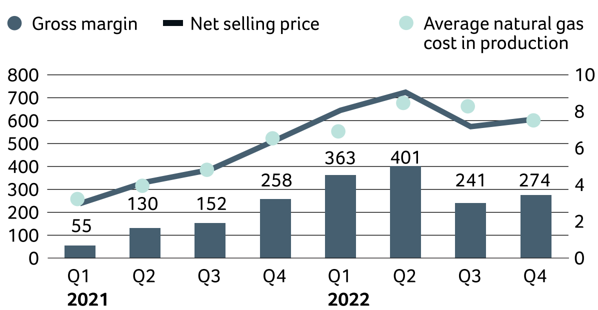
	2022 vs 2021
Overall gas cost	Gas prices in our cost of production increased in 2022 as a result of higher North American gas index prices and increased gas costs in Trinidad, where our gas prices are linked to ammonia benchmark prices.

Selected Nitrogen Measures

	2022	2021
Sales volumes (tonnes – thousands)		
Fertilizer	5,371	6,028
Industrial and feed	4,652	4,697
Net sales (millions of US dollars)		
Fertilizer	3,512	2,364
Industrial and feed	2,878	1,620
Net selling price per tonne		
Fertilizer	654	392
Industrial and feed	619	345

NITROGEN GROSS MARGIN, NET SELLING PRICE AND NATURAL GAS COST

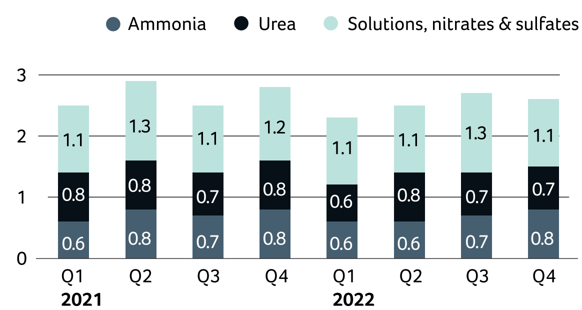
($ per tonne) ($ per MMBtu)



Source: Nutrien

NITROGEN SALES VOLUMES

(million tonnes)



Source: Nutrien

Nitrogen Production

(million tonnes product, except as otherwise noted)	Ammonia [1] Annual Capacity [3]	Ammonia [1] Production 2022	Ammonia [1] Production 2021	Urea [2] Annual Capacity [3]	Urea [2] Production 2022	Urea [2] Production 2021
Trinidad Nitrogen [4]	2.2	**1.46**	1.66	0.7	**0.42**	0.72
Redwater Nitrogen	0.9	**0.78**	0.72	0.7	**0.55**	0.53
Augusta Nitrogen	0.8	**0.59**	0.73	0.7	**0.40**	0.55
Lima Nitrogen	0.7	**0.71**	0.76	0.5	**0.50**	0.50
Geismar Nitrogen	0.5	**0.58**	0.50	0.4	**0.37**	0.33
Carseland Nitrogen	0.5	**0.39**	0.52	0.7	**0.50**	0.72
Fort Saskatchewan Nitrogen	0.5	**0.47**	0.46	0.4	**0.44**	0.41
Borger Nitrogen	0.5	**0.41**	0.25	0.6	**0.49**	0.31
Joffre Nitrogen	0.5	**0.37**	0.40	–	**–**	–
Total	7.1	**5.76**	6.00	4.7	**3.67**	4.07
Adjusted total [5]		**3.93**	3.94			
Ammonia operating rate [5] (%)		**90**	90			

1 All figures are shown on a gross production basis.
2 Reflects capacity and production of urea liquor prior to final product upgrade. Urea liquor is used in the production of solid urea, UAN and DEF.
3 Annual capacity estimates include allowances for normal operating plant conditions.
4 In 2022, Trinidad production was restricted due to natural gas curtailments, which is expected to extend into 2023.
5 Excludes Trinidad and Joffre.

Our Results and Outlook

2022 Phosphate Financial Performance

We generated record Phosphate adjusted EBITDA of $594 million as higher net realized selling prices more than offset higher raw material costs and lower sales volume. Global phosphate prices increased in the first half of 2022 due to global supply constraints, including export restrictions by China and uncertainty about Russian phosphate exports. The strength in first half shipments of 2022 led to an inventory build-up in key markets, which contributed to weakness in demand and prices in the second half of 2022. Higher raw material costs were driven by significantly higher sulfur and ammonia input costs, with a condensed North American spring application season and lower production volumes contributing to lower sales volumes.

	Dollars			Tonnes (thousands)			Average per Tonne		
(millions of US dollars, except as otherwise noted)	**2022**	2021	% Change	**2022**	2021	% Change	**2022**	2021	% Change
Manufactured product									
Net sales									
Fertilizer	**1,367**	1,108	23	**1,696**	1,840	(8)	**806**	602	34
Industrial and feed	**706**	520	36	**682**	779	(12)	**1,035**	667	55
	2,073	1,628	27	**2,378**	2,619	(9)	**872**	622	40
Cost of goods sold	**1,562**	1,227	27				**657**	469	40
Gross margin – manufactured	**511**	401	27				**215**	153	41
Gross margin – other [1]	**(18)**	20	n/m	**Depreciation and amortization**			**79**	58	37
Gross margin – total	**493**	421	17	**Gross margin excluding depreciation**					
(Income) expenses	**(693)**	36	n/m	**and amortization – manufactured** [2]			**294**	211	40
EBIT	**1,186**	385	208						
Depreciation and amortization	**188**	151	25						
EBITDA	**1,374**	536	156						
Adjustments [3]	**(780)**	4	n/m						
Adjusted EBITDA	**594**	540	10						

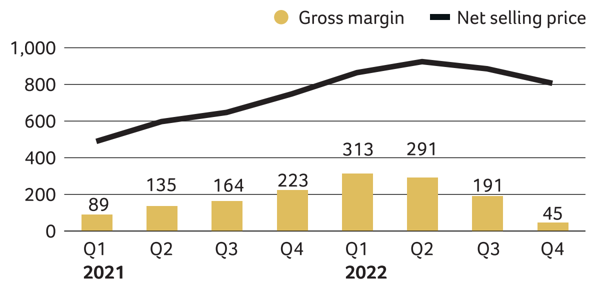
1 Includes other phosphate and purchased products and comprises net sales of $304 million (2021 – $201 million) less cost of goods sold of $322 million (2021 – $181 million).
2 This is a non-IFRS financial measure. See the "Non-IFRS Financial Measures" section.
3 See Note 3 to the consolidated financial statements. Includes impairment reversal of assets of $780 million (2021 – nil).

The most significant contributors to the changes in our Phosphate financial performance were as follows:

	2022 vs 2021
Sales volumes	Sales volumes decreased in 2022 due to a condensed North American spring application season and lower production volumes.
Net realized selling price	Average net realized selling prices increased in 2022 consistent with higher global benchmark prices.
Cost of goods sold per tonne	Costs increased in 2022 primarily due to higher sulfur and ammonia input costs, along with lower production volumes. Depreciation and amortization was also higher due to an increase in depreciable asset values resulting from asset impairment reversals (see details below).
(Income) expenses	In 2022, we recorded $780 million of impairment reversals relating to our property, plant and equipment at Aurora and White Springs of $450 million and $330 million, respectively, primarily due to higher forecasted global phosphate prices and a more favorable outlook for phosphate margins. The impairment reversals are included within (income) expenses and EBITDA in the table above and then deducted from adjusted EBITDA.
Adjusted EBITDA	Adjusted EBITDA increased in 2022 mainly due to higher net realized selling prices, which more than offset higher input costs and lower sales volumes.

PHOSPHATE GROSS MARGIN AND NET SELLING PRICE

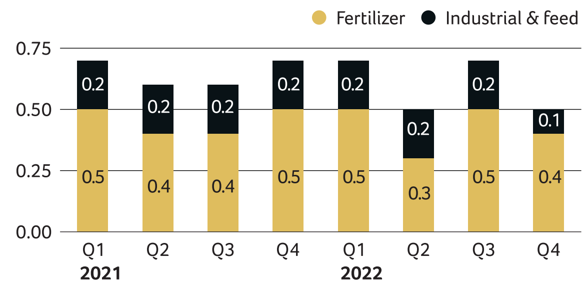
($ per tonne)



Source: Nutrien

PHOSPHATE SALES VOLUMES

(million tonnes)



Source: Nutrien

Phosphate Production

	Phosphate Rock			Phosphoric Acid (P_2O_5)			Liquid Products			Solid Fertilizer Products		
		Production			Production			Production			Production	
(million tonnes, except as otherwise noted)	Annual Capacity	**2022**	2021	Annual Capacity	**2022**	2021	Annual Capacity	**2022**	2021	Annual Capacity	**2022**	2021
Aurora Phosphate	5.4	**3.43**	3.77	1.2	**0.93**	1.05	2.7[1]	**1.87**	2.12	0.8	**0.68**	0.80
White Springs Phosphate	2.0	**1.42**	1.62	0.5	**0.42**	0.47	0.7[2]	**0.39**	0.44	0.8	**0.30**	0.40
Total	7.40	**4.85**	5.39	1.70	**1.35**	1.52	3.40	**2.26**	2.56	1.60	**0.98**	1.20
P_2O_5 operating rate (%)					**79**	89						

1 A substantial portion is consumed internally in the production of downstream products. The balance is exported to phosphate fertilizer producers or sold domestically to dealers who custom-mix liquid fertilizer. Capacity comprised of 2.0 million tonnes merchant grade acid and 0.7 million tonnes superphosphoric acid.

2 Represents annual superphosphoric acid capacity. A substantial portion is consumed internally in the production of downstream products. The balance is exported to phosphate fertilizer producers or sold domestically to dealers who custom-mix liquid fertilizer.

In addition to the production above, annual capacity (in millions of tonnes) for phosphate feed and purified acid was 0.7 and 0.3, respectively. Production in 2022 was 0.33 and 0.18, respectively, and 2021 production was 0.31 and 0.24, respectively.

Our Results and Outlook

2022 Corporate and Others Financial Performance

"Corporate and Others" is a non-operating segment comprising corporate and administrative functions that provide support and governance to our operating segments.

(millions of US dollars, except as otherwise noted)	2022	2021	% Change
Selling expenses	(1)	(21)	(95)
General and administrative expenses	326	275	19
Share-based compensation expense	63	198	(68)
Other expenses	227	253	(10)
EBIT	(615)	(705)	(13)
Depreciation and amortization	71	49	45
EBITDA	(544)	(656)	(17)
Adjustments [1]	146	348	(58)
Adjusted EBITDA	(398)	(308)	29

1 See Note 3 to the consolidated financial statements.

The most significant contributors to the changes in our Corporate and Others financial performance were as follows:

	2022 vs 2021
General and administrative expenses	Increase in expenses was mainly due to increased depreciation and amortization expense, higher donations and higher information technology-related expenses.
Share-based compensation expense	Decrease in expense was due to a decrease in the fair value of share-based awards outstanding relative to 2021.
Other expenses	Decrease in other expenses was mainly due to lower COVID-19 related expenses, the absence of cloud computing related expenses from our change in accounting policy in 2021, and lower expenses related to asset retirement obligations and accrued environmental costs for our non-operating sites from the changes in our cost and discount rate estimates. These factors were partially offset by higher information technology project feasibility costs and an employee special recognition award expense in 2022.

Eliminations

Eliminations are not part of the Corporate and Others segment. Eliminations of sales between operating segments in 2022 were $(2,333) million (2021 – $(1,612) million) with gross margin elimination of $(28) million (2021 – $(89) million). We had significant eliminations in 2021 due to higher-margin inventories held by our Retail segment as global commodity benchmark prices increased. The magnitude of the rise in prices was lower in 2022.

Finance Costs, Income Taxes and Other Comprehensive (Loss) Income

(millions of US dollars, except as otherwise noted)	2022	2021	% Change
Finance costs	563	613	(8)
Income tax expense	2,559	989	159
Other comprehensive (loss) income	(177)	78	n/m

The most significant contributors to the changes in our finance costs, income taxes and other comprehensive (loss) income were as follows:

2022 vs 2021

Finance costs

Finance costs decreased mainly due to the absence of a loss of $142 million on early extinguishment of a portion of our long-term debt in 2021. Short-term interest was higher in 2022 from increased interest rates and a higher average short-term debt balance compared to 2021, which more than offset a decrease in long-term interest due to a lower average outstanding balance in 2022.

Weighted Average Debt Balances and Rates

(millions of US dollars, except as otherwise noted)	2022	2021
Short-term balance [1]	3,975	648
Short-term rate (%) [1]	3.0	1.0
Long-term balance (excluding lease obligations)	7,839	9,689
Long-term rate (excluding lease obligations) (%)	4.6	4.5
Lease obligations balance	1,209	1,163
Lease obligations rate (%)	2.9	2.8

1 North American weighted average short-term debt balances were $3,529 million (2021 – $451 million) and rates were 2.6 percent (2021 – 0.2 percent).

Income tax expense

Income tax expense increased mainly due to higher earnings in 2022.

Effective Tax Rates and Discrete Items

(millions of US dollars, except as otherwise noted)	2022	2021
Actual effective tax rate on earnings (%)	25	24
Actual effective tax rate including discrete items (%)	25	24
Discrete tax adjustments that impacted the rate	30	(15)

Other comprehensive (loss) income

Other comprehensive loss in 2022 compared to income in 2021 was primarily driven by changes in the currency translation of our foreign operations and share price movement related to our investment in Sinofert Holdings Ltd ("Sinofert"). In 2022 we had fair value losses on our investment in Sinofert due to share price decreases, compared to fair value gains due to share price increases in 2021. In addition, we had higher losses on foreign currency translation of our Retail foreign operations, mainly in Canada, compared to 2021, as this currency depreciated relative to the US dollar, partially offset by higher gains in Brazil, as this currency appreciated relative to the US dollar.

Our Results and Outlook

Performance Against 2023 Targets

Executing on our financial and operating targets

We made good progress towards many of our financial metrics and plan on disclosing new long-term targets in the second half of 2023. As we enhance our Retail digital platform with new rollouts in the first half of 2023, we will evolve our digital targets to align with areas of focused grower engagement. Our Nitrogen sales volumes are expected to fall below our 2023 target of 11.5 to 12.0 million tonnes, due to the timing for completion of our brownfield projects and anticipation of Trinidad gas curtailments in 2023. We have updated our Nitrogen sales volume target to 10.8 to 11.4 million tonnes to align with our 2023 guidance range.

	2023 Targets	2022	2021
Nutrien Ag Solutions ("Retail")			
Total Retail adjusted EBITDA margin [1]	>10.5%	10.7%	10.9%
US Retail adjusted EBITDA margin [1,2]	–	12.2%	11.6%
Retail adjusted average working capital to sales [3]	17%	17%	13%
Retail cash operating coverage ratio [3]	60%	55%	58%
Retail adjusted EBITDA per US selling location (thousand dollars) [1,4]	>$1,100	$1,923	$1,481
Retail proprietary products as a % of total Retail margin	29%	24%	23%
Retail digital platform sales to total Retail sales [1,5]	>50%	18%	17%
Retail digital platform sales (million dollars) [1,2,5]	–	$2,837	$2,148
Potash and Nitrogen			
Potash sales volumes (million tonnes)	14.0-16.0	12.5	13.6
Potash controllable cash cost of product manufactured per tonne [2,3]	–	$58	$52
Nitrogen sales volumes (million tonnes) [6]	10.8-11.4	10.0	10.7
Ammonia operating rate [7]	96%	90%	90%
Ammonia controllable cash cost of product manufactured per tonne [3]	~$42	$59	$50
IFRS Comparable Information			
Potash cost of goods sold ("COGS") (million dollars) [2]	–	$1,400	$1,285
Nitrogen manufactured cost of goods sold ("COGS") (million dollars) [2]	–	$3,197	$2,353

1 This is a supplementary financial measure. See the "Other Financial Measures" section.
2 No target was provided.
3 This is a non-IFRS financial measure. See the "Non-IFRS Financial Measures" section.
4 Calculation is based on number of selling locations only, excluding acquisitions.
5 Digital Platform generated revenue includes grower and employee orders that are entered directly into the digital platform. North American digital Retail sales as a proportion of total North American Retail sales.
6 2023 target includes ESN® products that prior to 2023 were included in the other category.
7 Capacity utilization represents production volumes divided by production capacity (excluding Joffrey and Trinidad facilities).

Our Results and Outlook

2023 Market Outlook

Expect structural supply issues to persist and demand for crop inputs to increase in 2023

Agriculture and Retail

Agricultural fundamentals remain historically strong and are supported by the lowest global grain stocks-to-use ratio in over 25 years. We expect that Ukrainian crop production and exports will continue to be constrained by the impact of the war with Russia and it will take more than one growing season from the end of the war to alleviate the supply risk from the market. Spot prices for corn, soybeans and wheat are up 25 to 50 percent compared to the 10-year average, which we expect will support grower returns and provide an incentive to increase production in 2023.

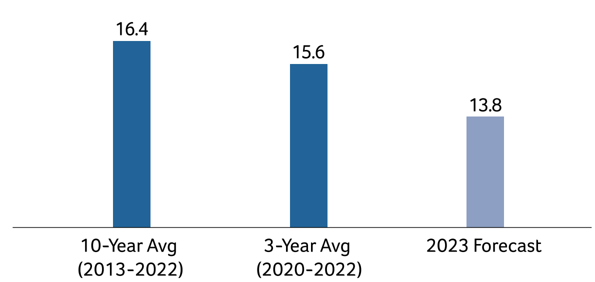
We anticipate that US major crop acreage will increase by approximately 4 percent in 2023, assuming a more normal planting window compared to the spring of 2022. We expect corn plantings to increase from approximately 89 million acres in 2022 to between 91 to 93 million acres in 2023.

Brazilian grower economics for soybeans and corn are strong, which we expect will support another year of above-trend acreage growth in that market. Australian growers have benefited from multiple years of above-average yields and historically high crop prices, positioning them very well financially entering 2023, and we would expect another year of strong production assuming favorable weather conditions.

Nutrien Ag Solutions 2023 adjusted EBITDA guidance assumes strong demand for crop inputs in each of the markets we serve. We expect gross margins for crop nutrients and crop protection will be lower in 2023 compared to record levels achieved in 2022.

GLOBAL GRAIN STOCKS/USE RATIO

(% (excluding China)[1])

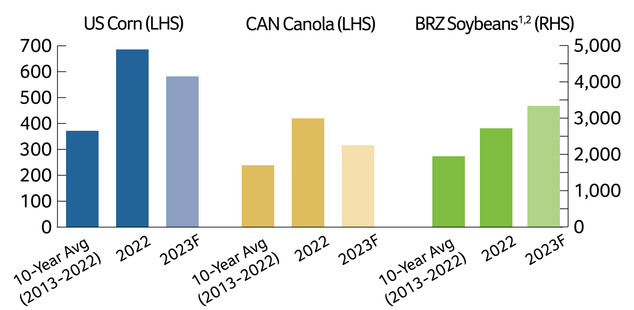


Source: USDA, Nutrien

1 Excluding China, grains refer to barley, corn, millet, mixed grain, oats, rice, rye, sorghum and wheat.

KEY CROP GROWER CASH MARGINS

(local currency margin/acre)



Source: USDA, IMEA, Bloomberg, ICE, Nutrien

1 Brazil is local currency margin/hectare.

2 Due to crop year timing in Brazil the 2022 references the 2022/23 crop year, which was planted in Q3 & Q4 2022 with growers realizing returns in 2023. The 2023F references the 2023/24 crop year.

Potash

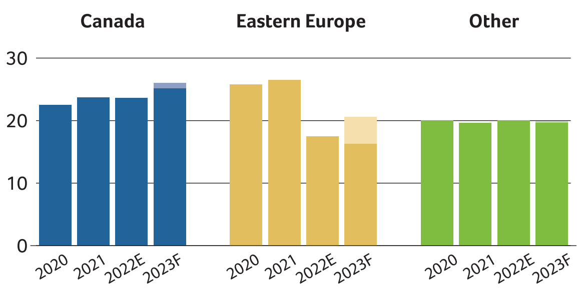
We believe potash inventories have been drawn down in Brazil and the US following a historic decline in the pace of potash shipments in the second half of 2022. We have seen improved potash demand in early 2023, however buyers continue to take a cautious approach to managing inventories that could lead to a more condensed shipment period as we approach the primary application seasons. Our estimate for global potash shipments in 2023 is 63 to 67 million tonnes, which is still constrained compared to the historical trend demand estimated at around 70 million tonnes.

Belarus potash shipments in 2023 are projected to be down 40 to 60 percent and Russian shipments down 15 to 30 percent compared to 2021. We anticipate the reduction in supply will be most apparent in the first quarter of 2023 compared to the same period in 2022, as both Belarusian and Russian exports were heavily weighted to early 2022 before sanctions and export restrictions were imposed.

Nutrien's potash sales tonnes guidance of 13.8 to 14.6 million tonnes assumes increased demand in our key markets of North America and Brazil and continue global supply constraints in 2023. We have maintained capability to increase sales volumes to our previous expectation of approximately 15 million tonnes if we see stronger demand in the market.

POTASH PRODUCTION IN SELECTED REGIONS [1]

(millions of tonnes KCl)

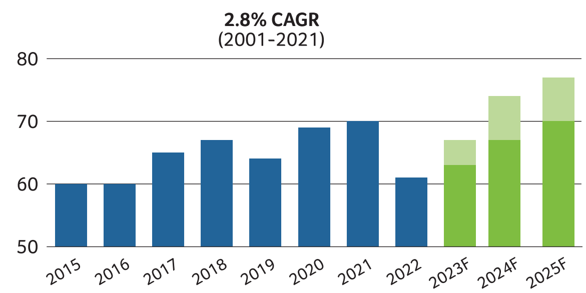


Source: CRU, Fertecon, IFA, Nutrien

1 Production changes differ from our expectations in operational capability.

GLOBAL POTASH DEMAND

(millions of tonnes KCl)



Source: CRU, Fertecon, IFA, Nutrien

Nitrogen

Global nitrogen prices have declined during the first two months of 2023 due to lower European natural gas prices and buyer deferrals. We expect European natural gas prices to be volatile throughout the year with around 30 percent of the regions' nitrogen capacity offline at the beginning of 2023. North American gas prices remain highly competitive compared to Europe and Asia and we expect Henry Hub prices to average between $2.50 and $4.50 per MMBtu in 2023.

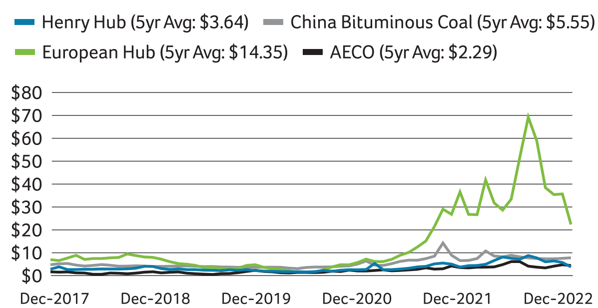
Nitrogen supply constraints, including lower Russian ammonia exports, reduced European operating rates and Chinese urea export restrictions are expected to persist in 2023, all of which we expect to have an impact on pricing volatility in periods of high seasonal demand. We expect a tight US supply and demand balance ahead of the spring season due to higher corn acreage and increased nitrogen exports over the past six months.

Global economic growth is a potential risk to industrial demand in 2023. Macroeconomic pressures impacted Asian markets throughout 2022 and there is the potential that the reopening of the Chinese economy has a positive impact on economic growth in the region later in 2023, depending on the impacts of COVID-19 and related policy decisions.

Nutrien's nitrogen sales tonnes guidance of 10.8 to 11.4 million tonnes in 2023 assumes higher operating rates at our North American plants and a continuation of gas curtailments in Trinidad in 2023. Nitrogen sales tonnes guidance includes 300,000 to 350,000 tonnes of projected ESN® product sales that prior to 2023 were included in the other product category.

ENERGY FEEDSTOCK PRICES

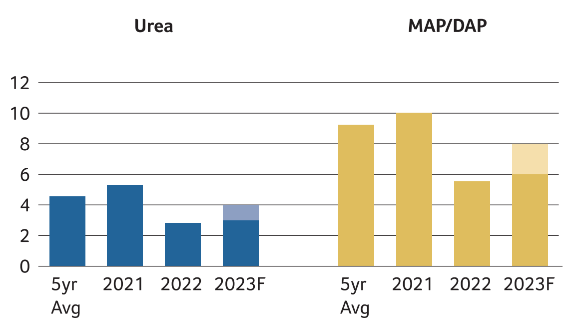
(US$/MMBtu)



Source: Fertecon, US EIA, Canadian Gas Price Reporter, CRU, Argus, Bloomberg, Nutrien

CHINA EXPORTS

(millions of tonnes)



Source: Datamyne, Fertilizer Week, Nutrien

Phosphate

We expect Chinese phosphate export restrictions to be in place until at least April 2023, anticipate improved demand in North America and Brazil, and the continuation of strong demand in India. Phosphate product margins are expected to be supported by lower raw material sulfur prices due to reduced operating rates and demand in China.

2023 Guidance

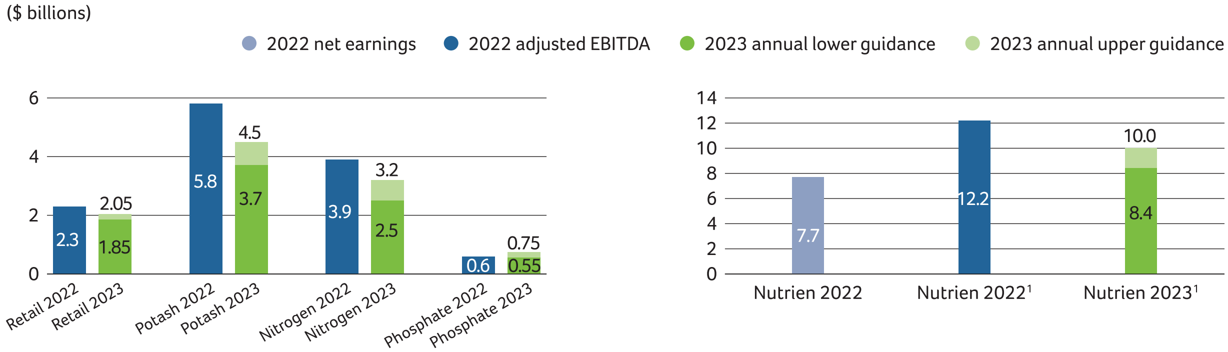
(billions of US dollars, except as otherwise noted)	2023 Guidance Ranges [1] Low	High
Adjusted net earnings per share in US dollars ("Adjusted EPS") [2,3]	8.45	10.65
Adjusted EBITDA [2]	8.4	10.0
Retail adjusted EBITDA	1.85	2.05
Potash adjusted EBITDA	3.7	4.5
Nitrogen adjusted EBITDA	2.5	3.2
Phosphate adjusted EBITDA (in millions of US dollars)	550	750
Potash sales tonnes (millions) [4]	13.8	14.6
Nitrogen sales tonnes (millions) [4]	10.8	11.4
Depreciation and amortization	2.1	2.2
Effective tax rate on adjusted earnings (%)	23.5	24.5

1 See the "Forward-Looking Statements" section.
2 These are non-IFRS financial measures. See the "Non-IFRS Financial Measures" section.
3 Assumes 503 million shares outstanding for all EPS guidance and sensitivities.
4 Manufactured product only. Nitrogen sales tonnes guidance includes ESN® products that prior to 2023 were included in the other category.

Assumptions

2023 Average Canadian to US dollar exchange rate	1.33
2023 NYMEX natural gas (US dollars per MMBtu)	~3.50

ADJUSTED EBITDA GUIDANCE
($ billions)



Source: Nutrien
1 These are non-IFRS financial measures. See the "Non-IFRS Financial Measures" section.

2023 Sensitivities

Price and Volume Sensitivities

(millions of US dollars, except EPS amounts)		Effect on Adjusted EPS	Adjusted EBITDA
Price	Potash changes by $25/tonne	± 0.45	± 300
	Ammonia changes by $25/tonne	± 0.07	± 50
	Urea changes by $25/tonne	± 0.12	± 80
	Solutions, nitrates and sulfates changes by $25/tonne	± 0.20	± 130
Volume	Potash changes by 100,000 tonnes	± 0.04	± 30
	Nitrogen changes by 50,000 N tonnes	± 0.03	± 20
Retail	Crop nutrients changes by 1% [1]	± 0.15	± 100
	Crop protection changes by 1% [1]	± 0.12	± 80
	Seed changes by 1% [1]	± 0.03	± 20

1 Gross margin as a percentage of sales.

Input Cost Sensitivities

(millions of US dollars, except EPS amounts)	Effect on Adjusted EPS	Adjusted EBITDA
NYMEX natural gas price changes by $1/MMBtu (impact on Nitrogen)	± 0.27	± 180
Canadian to US dollar changes by $0.02	± 0.01	± 5

Our Results and Outlook

Financial Highlights

(millions of US dollars, except as otherwise noted)	2022	2021	2020
Sales	37,884	27,712	20,908
Net earnings	7,687	3,179	459
Basic net earnings per share (US dollars)	14.22	5.53	0.81
Diluted net earnings per share (US dollars)	14.18	5.52	0.81
Total assets	54,586	49,954	47,192
Total non-current financial liabilities	8,939	8,455	10,947
Dividends declared per share (US dollars)	1.92	1.84	1.80

	2022 vs 2021	2021 vs 2020
Sales	Sales increased primarily due to higher net realized selling prices from global supply uncertainties across our nutrient segments, partially offset by lower sales volumes. Strong Retail performance due to higher selling prices and increased sales of proprietary products, which more than offset a reduction in crop nutrients sales volumes from a delayed North American planting season and earlier engagement in the prior year in a rising price environment.	Sales increased due to strong demand for global crop inputs and tight global fertilizer supply resulting in higher net realized selling prices across our segments and higher Potash sales volumes.
Net earnings and earnings per share	Net earnings and earnings per share increased due to higher gross margins from higher net realized selling prices across our nutrient segments and strong Retail performance supported by the strength of agriculture fundamentals, partially offset by higher operating costs, including provincial mining taxes, Retail selling expenses, royalties, natural gas and other input costs. In 2022, we recorded non-cash impairment reversals of our Phosphate property, plant and equipment at the Aurora and White Springs facilities.	Net earnings and earnings per share increased in 2021 compared to 2020 due to higher gross margins from higher net realized selling prices. In 2020, we recorded a non-cash impairment of our Phosphate property, plant and equipment at Aurora and White Springs facilities and a net gain from disposal of our investment in Misr Fertilizers Production Co SAE ("MOPCO"), which we did not incur in 2021.
Assets and non-current financial liabilities	Total assets increased approximately 10 percent from 2021. Our working capital assets increased due to higher sales and input costs along with acquisition impacts resulting in higher receivables and inventories. Property, plant and equipment increased primarily due to impairment reversals in the Phosphate segment. Non-current financial liabilities increased due to the higher long-term debt from the issuance of new notes.	Total assets increased slightly from 2020. Our working capital assets increased due to higher actual and anticipated sales activity resulting in higher receivables, inventories and prepaid expenses. Non-current financial liabilities decreased due to the early extinguishment of debt in 2021. The COVID-19 pandemic had a limited impact on our financial condition as at December 31, 2021 and 2020.
Dividends declared per share	Dividends declared per share increased as we declared a quarterly dividend per share of $0.48 in 2022 compared to $0.46 in 2021.	Dividends declared per share increased as we declared a quarterly dividend per share of $0.46 in 2021 compared to $0.45 in 2020.

Financial Condition Review

Balance Sheet Analysis

Assets	Liabilities
For information regarding changes in cash and cash equivalents, refer to the "Sources and Uses of Cash" section and the consolidated statements of cash flows in our consolidated financial statements. Receivables increased due to higher sales across all of our segments. The increase was mainly from our Retail segment, the result of higher crop nutrient net realized selling prices and increased usage of Nutrien Financial programs. Receivables also increased due to the recent Retail acquisitions in Brazil, primarily from Casa do Adubo S.A. ("Casa do Adubo"). Inventories increased due to higher costs to produce and/or purchase inventory across all our segments. Property, plant and equipment increased due to impairment reversals in our Phosphate segment.	Short-term debt increased due to higher borrowings under our credit facilities as part of our working capital management and for share repurchases. Long-term debt (including the current portion thereof) increased due to the addition of $1 billion in notes issued in November 2022, which exceeded the repayment of $500 million in notes upon maturity in October 2022. Payables and accrued charges increased due to higher payables balances from rising input costs due to inflation and tight global supply, extended Retail payment terms for crop nutrients, along with a higher income tax payable balance due to higher earnings. The recent acquisition of Casa do Adubo also contributed to the increase. Deferred income tax liabilities increased due to accelerated deductions for income tax purposes primarily related to property, plant and equipment. **Shareholders' Equity** Share capital decreased from shares repurchased under our normal course issuer bid program partially offset by exercise of stock options. Retained earnings increased as net earnings exceeded dividends declared and share repurchases.

We do not hold material cash and cash equivalents in currencies other than the US dollar and Canadian dollar. We held approximately $315 million US dollar equivalent in other jurisdictions outside the US and Canada. We do not depend on repatriation of cash from our foreign subsidiaries to meet our liquidity and capital resource needs in North America.

Liquidity and Capital Resources

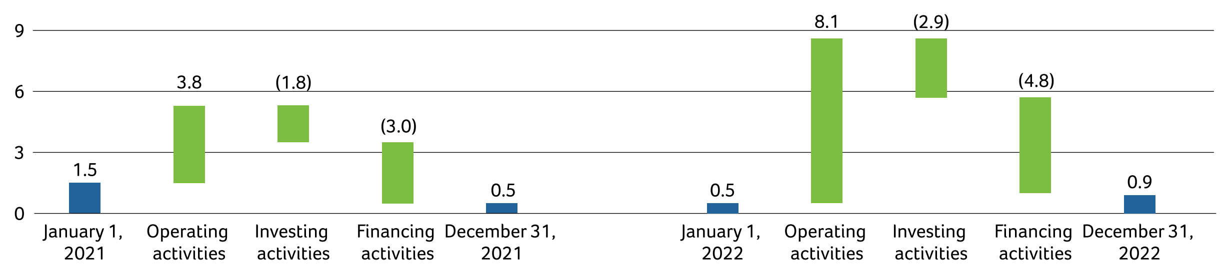
Sources and Uses of Liquidity

Liquidity risk arises from our general funding needs and in the management of our assets, liabilities and capital structure. We manage liquidity risk to maintain sufficient liquid financial resources to fund our financial position and meet our commitments and obligations in a cost-effective manner. Our 2022 significant liquidity sources are listed below along with our expected ongoing primary uses of liquidity:

Primary Uses of Liquidity	Primary Sources of Liquidity
• inventory purchases and production • operational expenses • seasonal working capital requirements • investing to sustain and grow our safe, reliable and cost-efficient operations through sustaining and investing capital • business acquisitions • returning cash to our shareholders through dividends and share repurchases (see Note 23 to the consolidated financial statements) • principal payments of debt securities (see Note 18 to the consolidated financial statements)	• cash from operations (including customer prepayments) • commercial paper issuances • increase of credit facility limits and drawdowns • debt capital markets

CASH FLOWS 2021 & 2022

($ billions)



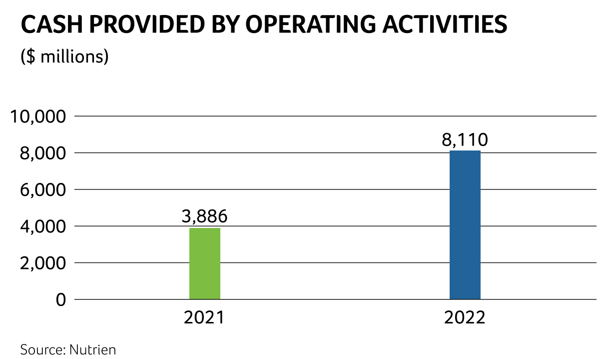
Source: Nutrien

We believe that our internally generated cash flow, supplemented by available borrowings under new or existing financing sources, if necessary, will be sufficient to meet our anticipated capital expenditures, planned growth and development activities, and other cash requirements for the foreseeable future. We do not reasonably expect any presently known trend or uncertainty to affect our ability to access our historical sources of liquidity.

Sources and Uses of Cash

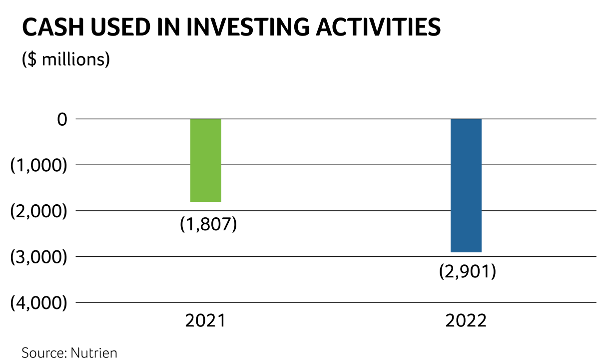
(millions of US dollars, except as otherwise noted)	2022	2021	% Change
Cash provided by operating activities	8,110	3,886	109
Cash used in investing activities	(2,901)	(1,807)	61
Cash used in financing activities	(4,731)	(3,003)	58
Effect of exchange rate changes on cash and cash equivalents	(76)	(31)	145
Increase (decrease) in cash and cash equivalents	402	(955)	n/m

Cash provided by operating activities



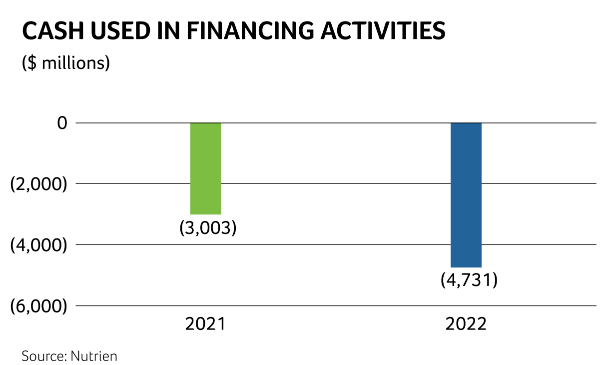
- Higher cash provided by operating activities due to higher net realized selling prices across our nutrient segments and strong Retail performance supported by the strength of agriculture fundamentals, partially offset by higher working capital needs due to higher costs to purchase and produce inventory and higher receivables balance from higher sales.

Cash used in investing activities



- Higher cash used in investing activities due to higher capital expenditures, in order to maintain the safety and reliability of assets in our Nitrogen segment and to increase our potash production capabilities, along with investments in our brownfield expansion plans and decarbonization projects.
- Higher spending on business acquisitions primarily due to our Casa do Adubo acquisition in Brazil in the fourth quarter of 2022, with no similarly sized acquisition in 2021.

Cash used in financing activities



- Higher cash used in financing activities due to increased share repurchases as we focused on shareholder returns in 2022.
- Short-term debt increased from higher borrowings under our credit facilities in 2022 as part of our seasonal working capital requirements and to temporarily support repurchases of common shares through our normal course issuer bid program.
- Net long-term debt proceeds in 2022 due to issuance of an aggregate of $1 billion in notes compared to a net long-term debt repayment in 2021 from the early extinguishment of $2 billion in debt.

Cash Requirements

The following aggregated information about our contractual obligations and other commitments summarizes our liquidity and capital resource requirements as at December 31, 2022:

		Payments Due by Period				
(millions of US dollars)	Financial Statement Note Reference	Total	Within 1 Year	1 to 3 Years	3 to 5 Years	Over 5 Years
Long-term debt	Notes 18, 26	8,344	542	1,573	675	5,554
Estimated interest payments on long-term debt	Note 26	5,076	390	719	574	3,393
Lease liabilities	Notes 19, 26	1,204	305	384	172	343
Estimated interest payments on lease liabilities	Note 26	170	32	43	27	68
Purchase commitments	Note 26	1,749	1,533	72	24	120
Capital commitments	Note 26	218	178	40	–	–
Other commitments	Note 26	444	169	143	74	58
Derivatives	Note 10	35	35	–	–	–
Asset retirement obligations and accrued environmental costs [1]	Note 22	4,023	213	184	114	3,512
Total		21,263	3,397	3,158	1,660	13,048

1 Commitments reflect the estimated cash outflows for these obligations. See Note 22 to the consolidated financial statements for details.

The information presented in the table above excludes:

- planned (but not legally committed) cash requirements;
- annual outflows for sustaining capital expenditures, business acquisitions and shareholder returns including share repurchases and dividends; and
- estimated capital investment requirements of more than $500 million by 2030 to achieve our 30 percent operational GHG emissions intensity reduction target. Specific project execution will depend on a range of factors, including the final investment decision with respect to the Geismar, Louisiana clean ammonia plant.

For information on income taxes and pension and other post-retirement benefits funding, refer to Note 8 and Note 21, respectively, to the consolidated financial statements. Future cash requirements are subject to changes in regulations, actuarial assumptions and our expected operating results.

On February 15, 2023, our Board approved a share repurchase program of up to a maximum of 24,962,194 representing 5 percent of Nutrien's outstanding common shares. Subject to acceptance by the TSX, the 2023 share repurchase program will commence on March 1, 2023, and will expire on the earlier of February 29, 2024, the date on which we have acquired the maximum number of common shares allowable or the date we determine not to make any further repurchases.

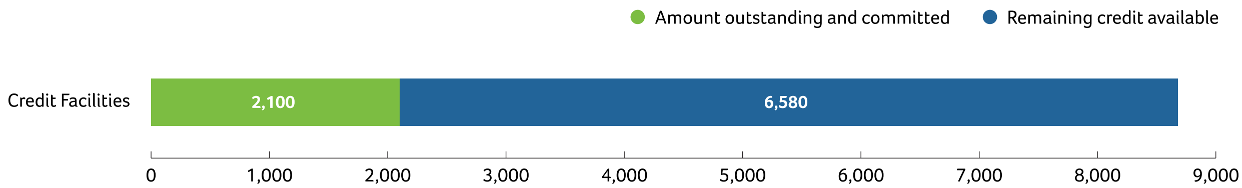
Capital Structure and Management

We manage our capital structure with a focus on maintaining a strong balance sheet, enabling a strong investment-grade credit rating.

Principal Debt Instruments

We use a combination of cash generated from operations and short-term and long-term debt to finance our operations. As at December 31, 2022, we had the following debt instruments available:

CREDIT FACILITIES
As at December 31, 2022
($ millions)



Source: Nutrien

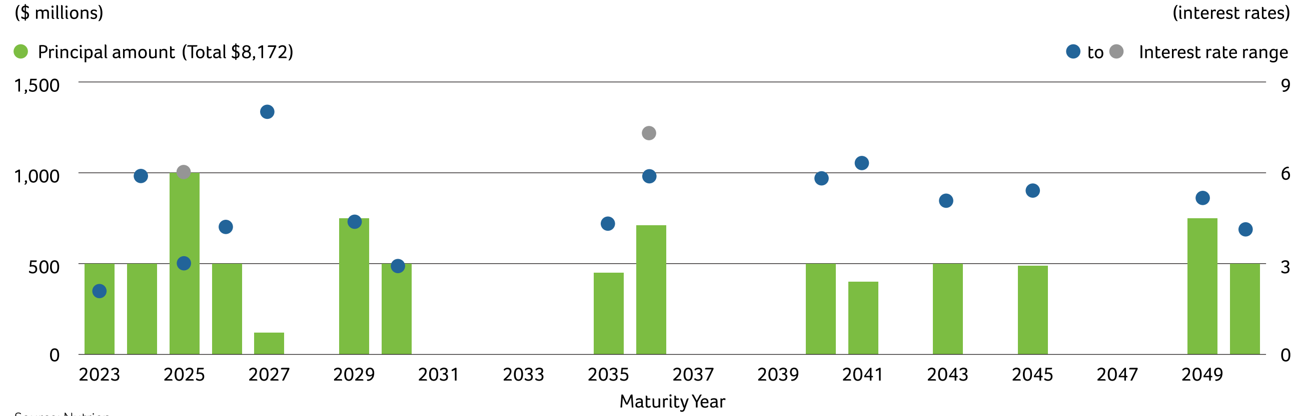
			Outstanding and Committed			
			Short-Term		Long-Term	
(millions of US dollars, except as otherwise noted)	Rate of Interest (%)	Total Facility Limit	**As at December 31, 2022**	As at December 31, 2021	**As at December 31, 2022**	As at December 31, 2021
Credit facilities						
Unsecured revolving term credit facility [1]	n/a	4,500	–	–	–	–
Unsecured revolving term credit facility [2]	5.3	2,000	500	–	–	–
Uncommitted revolving demand facility [3]	n/a	1,000	–	–	–	–
Other credit facilities		1,180				
South America	1.3–76.0		453	74	162	137
Australia	3.9		190	211	–	–
Other	2.1–4.0		9	28	3	4
Commercial paper	4.8–5.2		783	1,170	–	–
Other short-term and long-term debt	n/a		207	77	7	–
Total			2,142	1,560	172	141

1 In 2022, we extended the maturity date from June 4, 2026 to September 14, 2027, subject to extension at the request of Nutrien provided that the resulting maturity date may not exceed five years from the date of request.
2 In 2022, we entered into a new $2,000 unsecured revolving term credit facility, with the same principal covenants and events of default as our existing $4,500 unsecured revolving term credit facility.
3 In 2022, we increased our uncommitted revolving demand facility limit by $500.

Our commercial paper program is limited to the undrawn availability of backup funds under the $4,500 million unsecured revolving term credit facility and excess cash invested in highly liquid securities. As at December 31, 2022, $227 million in letters of credit were outstanding and committed, with $145 million of remaining credit available.

Our long-term debt consists primarily of notes and debentures with the following maturities and interest rates:

NOTES AND DEBENTURES MATURITIES AND RATES
As at December 31, 2022
($ millions)



Source: Nutrien

On October 1, 2022, we repaid $500 million in principal amount of our notes. On November 7, 2022, we issued $500 million principal amount of 5.90 percent notes due in 2024 and $500 million principal amount of 5.95 percent notes due in 2025. See Note 18 to the consolidated financial statements.

We also have lease obligations totaling $1,204 million (including current portion) with a weighted average effective interest rate of 3.2 percent as at December 31, 2022.

Debt Covenants

Our credit facilities have financial tests and other covenants with which we must comply at each quarter-end. Non-compliance with any such covenants could result in accelerated payment of amounts borrowed and termination of lenders' further funding obligations under the credit facilities. We were in compliance with all such covenants as at December 31, 2022.

The table below summarizes the limit and result of our key financial covenant:

As at December 31	Limit	2022
Debt to capital ratio [1]	0.65 : 1.00	0.32 : 1.00

1 Refer to Note 24 to the consolidated financial statements for the detailed calculation.

Credit Ratings

Our ability to access reasonably priced debt in the capital markets depends, in part, on the quality of our credit ratings. We continue to maintain investment-grade credit ratings for our long-term debt. A downgrade of the credit rating of our long-term debt could increase the interest rates applicable to borrowings under our credit facilities.

Commercial paper markets are normally a source of same-day cash for us. Our access to the US commercial paper market primarily depends on maintaining our current short-term credit ratings as well as general conditions in the money markets.

	Long-Term Debt Rating (Outlook)		Short-Term Debt Rating	
As at December 31,	**2022**	2021	**2022**	2021
Moody's	Baa2 (stable)	Baa2 (stable)	P-2	P-2
S&P	BBB (positive)	BBB (stable)	A-2	A-2

A credit rating is not a recommendation to buy, sell or hold securities. Such ratings may be subject to revision or withdrawal at any time by the respective credit rating agency and each rating should be evaluated independently of any other rating.

S&P's positive outlook on Nutrien's credit ratings means that the ratings may be raised over the intermediate term (typically six months to two years).

Outstanding Share Data

	February 16, 2023
Common shares	499,243,897
Options to purchase common shares	3,884,894

For more information on our capital structure and management, see Note 24 to the consolidated financial statements.

For more information on our short-term and long-term debt, see Note 17 and Note 18 to the consolidated financial statements.

Off-Balance Sheet Arrangements

Principal off-balance sheet activities primarily include:

- Agreement to reimburse losses of Canpotex (see Note 29 to the consolidated financial statements).
- Issuance of guarantee contracts (see Note 22 and Note 27 to the consolidated financial statements).
- An agency arrangement with a financial institution in relation to certain customer loans (see Note 10 and Note 11 to the consolidated financial statements).
- Certain non-financial derivatives that were entered into and continued to be held for the purpose of the receipt or delivery of a non-financial item in accordance with expected purchase, sale or usage requirements. Other derivatives are included on our balance sheet at fair value (see Note 10 to the consolidated financial statements).

We do not reasonably expect any presently known trend or uncertainty to affect our ability to continue using these arrangements, except as indicated above.

Other Financial Information

Related Party Transactions

Our most significant related party is Canpotex, which provides us with low-cost marketing and logistics for the offshore potash markets that we serve. Refer to Note 28 to the consolidated financial statements for information on our related party transactions.

Market Risks Associated With Financial Instruments

Market risk is the potential for loss from adverse changes in the market value of financial instruments. The level of market risk to which we are exposed varies depending on the composition of our derivative instrument portfolio, as well as current and expected market conditions. See Note 10 to the consolidated financial statements for information on our financial instruments, including the risks and risk management associated with such instruments.

Critical Accounting Estimates

We prepare our consolidated financial statements in accordance with IFRS, which requires us to make judgments, assumptions and estimates in applying accounting policies. Critical accounting estimates are those which are highly uncertain at the time they are made or where different estimates would be reasonably likely to have a material impact on our financial condition or results of operations. We have discussed the development, selection and application of our key accounting policies, and the critical accounting estimates and assumptions they involve, with the Audit Committee of the Board.

Refer to the notes to the consolidated financial statements for additional information on the following critical accounting estimates including methodology used for calculating our estimates (when applicable), key assumptions used, and factors considered in our estimates and judgments.

In 2022, we amended our critical accounting estimates to exclude long-lived asset impairment and reversals because, during the year, we fully reversed the previously recorded impairments related to property, plant and equipment at Aurora and White Springs. Refer to Note 13 to the consolidated financial statements for further details.

Financial Statement Reference	Critical Accounting Estimate Description
Note 14 and Note 30	**Goodwill impairment indicators** We test our operating segments that have goodwill allocated to them when events or circumstances indicate that there could be an impairment, or at least annually. Based on our assumptions at the time of our impairment testing, the recoverable amount of each of our CGUs or groups of CGUs was greater than or approximately equal to their carrying amounts. The key assumptions with the greatest influence on the calculation of the recoverable amounts are the discount rates, terminal growth rates and cash flow forecasts. The key forecast assumptions were based on historical data and our estimates of future results from internal sources considering industry and market trends. Key assumptions in our testing models may change, and changes that could reasonably be expected to occur may cause impairment. Such change in assumptions could be driven by global supply and demand, other market factors, changes in regulations, and other future events outside our control. The Retail – North America group of CGUs have \$6.9 billion in associated goodwill. In 2022, North American central banks increased their benchmark borrowing rates; these rates are a component of our discount rate for impairment testing. As a result of these increases, we revised our discount rates throughout 2022, which triggered impairment testing for our Retail – North America group of CGUs as at June 30, 2022 and September 30, 2022. No impairment was recognized during these interim testing periods. Goodwill is more susceptible to impairment risk if there is an increase in the discount rate, or a deterioration in business operating results or economic conditions and actual results do not meet our forecasts. As at September 30, 2022, the Retail – North America group of CGUs carrying amount approximated its recoverable amount. A 25 basis point increase in the discount rate would have resulted in an impairment of the carrying amount of goodwill of approximately \$500 million. A decrease in forecasted EBITDA and cash flows or a reduction in the terminal growth rate could result in impairment in the future.

Financial Statement Reference	Critical Accounting Estimate Description
Note 8, Note 29 and Note 30	**Income taxes – measurement** Significant estimates for the measurement of our income taxes include assessing the probability and measurement of our uncertain tax provisions related to complex global tax regulations and assessing the probability of future taxable income used to recognize deferred tax assets. Although we believe our assumptions and estimates are reasonable, our tax assets are realizable, and our accruals for tax liabilities are adequate for all open tax years based on our interpretation of tax laws and prior experience, actual results could differ. Changes in the income tax legislations, regulations and interpretations may result in a material impact on our consolidated financial statements. Income taxes are recorded in our Corporate and Others segment.
Note 22 and Note 30	**Asset retirement obligations ("AROs") and accrued environmental costs ("ERLs") – measurement** The Potash and Phosphate segments have AROs and ERLs (which have a high degree of estimation uncertainty for future costs and estimated timelines) associated with their mining operations while the Corporate and Others segment has these liabilities associated with non-operational mines. For the Nitrogen segment, we have not recorded any AROs as no significant asset retirement obligations have been identified or there is no reasonable basis for estimating a date or range of dates of cessation of operations. We considered the historical performance of our facilities as well as our planned maintenance, major upgrades and replacements, which can extend the useful lives of our facilities indefinitely.

Quarterly Results

(millions of US dollars, except as otherwise noted)	2022 Q4	2022 Q3	2022 Q2	2022 Q1	2021 Q4	2021 Q3	2021 Q2	2021 Q1
Sales	7,533	8,188	14,506	7,657	7,267	6,024	9,763	4,658
Net earnings	1,118	1,583	3,601	1,385	1,207	726	1,113	133
Net earnings attributable to equity holders of Nutrien	1,112	1,577	3,593	1,378	1,201	717	1,108	127
Net earnings per share attributable to equity holders of Nutrien								
Basic	2.15	2.95	6.53	2.49	2.11	1.26	1.94	0.22
Diluted	2.15	2.94	6.51	2.49	2.11	1.25	1.94	0.22

Seasonality in our business results from increased demand for products during the planting season. Crop input sales are generally higher in the spring and fall application seasons. Crop nutrient inventories are normally accumulated leading up to each application season. Our cash collections generally occur after the application season is complete, while customer prepayments made to us are concentrated in December and January and inventory prepayments paid to our vendors are typically concentrated in the period from November to January. Feed and industrial sales are more evenly distributed throughout the year.

Our earnings are significantly affected by fertilizer benchmark prices, which have been volatile over the last two years and are affected by demand-supply conditions, grower affordability and weather.

In the second and third quarters of 2022, earnings were impacted by $450 million and $330 million non-cash impairment reversals at Aurora and White Springs, respectively, of property, plant and equipment in the Phosphate segment related to higher forecasted global prices and a more favorable outlook for phosphate margins. In the fourth quarter of 2021, earnings were impacted by a $142 million loss resulting from the early extinguishment of long-term debt.

Fourth Quarter Financial Performance

(millions of US dollars, except as otherwise noted)	Sales			Gross Margin		
Three months ended December 31	**2022**	2021	% Change	**2022**	2021	% Change
Retail						
Crop nutrients	**2,320**	2,035	14	**349**	428	(18)
Crop protection products	**981**	1,113	(12)	**413**	414	–
Seed	**251**	189	33	**46**	57	(19)
Merchandise	**264**	270	(2)	**41**	45	(9)
Nutrien Financial	**62**	51	22	**62**	51	22
Services and other [1]	**237**	243	(2)	**194**	201	(3)
Nutrien Financial elimination [1,2]	**(28)**	(23)	22	**(28)**	(23)	22
Total	**4,087**	3,878	5	**1,077**	1,173	(8)

1 Certain immaterial figures have been reclassified for the three months ended December 31, 2021.
2 Represents elimination for the interest and service fees charged by Nutrien Financial to Retail branches.

(US dollars, except as otherwise noted)	Manufactured Product Sales Tonnes (thousands)			Manufactured Product Average per Tonne		
Three months ended December 31	**2022**	2021	% Change	**2022**	2021	% Change
Potash						
North America	**959**	1,002	(4)	**560**	494	13
Offshore	**1,659**	2,054	(19)	**506**	450	12
Sales	**2,618**	3,056	(14)	**526**	465	13
Cost of goods sold				**118**	100	18
Gross margin				**408**	365	12
Nitrogen						
Ammonia	**776**	790	(2)	**887**	656	35
Urea	**705**	824	(14)	**657**	670	(2)
Solutions, nitrates and sulfates	**1,056**	1,221	(14)	**368**	316	16
Sales	**2,537**	2,835	(11)	**607**	514	18
Cost of goods sold				**333**	256	30
Gross margin				**274**	258	6
Phosphate						
Fertilizer	**391**	509	(23)	**700**	741	(6)
Industrial and feed	**140**	202	(31)	**1,107**	766	45
Sales	**531**	711	(25)	**807**	749	8
Cost of goods sold				**762**	526	45
Gross margin				**45**	223	(80)

Highlights of our 2022 fourth quarter compared to the 2021 fourth quarter results were as follows:

	Q4 2022 vs Q4 2021
Retail	Gross margin decreased in 2022 compared to the record quarter experienced in 2021 as strong sales in most product categories were offset by lower volumes and higher cost of inventory. Crop nutrients sales increased in 2022 due to higher selling prices and gross margin decreased due to the higher cost of inventory relative to 2021. Crop protection products gross margin was flat as higher sales pricing and a favorable sales mix in North America offset a decline in sales volumes compared to a very strong period of demand in 2021. Seed sales increased in 2022 due to higher pricing along with strong North America corn sales, South America soybean sales and Australia canola sales. Seed gross margin decreased in 2022 attributed to the timing and mix of seed sales compared to the same period in 2021.
Potash	Gross margin decreased due to lower volumes from cautious purchasing in a declining pricing environment partially offset by higher net realized selling prices. Cost of goods sold per tonne increased due to lower production, a pull forward of maintenance activities, higher royalties due to higher net selling prices and higher supply costs resulting from inflation.
Nitrogen	Gross margin decreased due to lower sales volumes and higher costs more than offsetting higher net realized selling prices. Volumes decreased primarily due to natural gas curtailments in Trinidad and unplanned plant outages that included the impact of extreme cold weather in the quarter and cautious buyer activity. Cost of goods sold per tonne increased due to higher natural gas, higher raw material costs and other operating costs further impacted by production outages.
Phosphate	Gross margin decreased due to lower sales volumes more than offsetting higher industrial and feed net realized selling prices. Volumes decreased as a result of unplanned production outages, which reduced operating rates. Cost of goods sold per tonne increased due to higher raw material input costs combined with higher costs from the production outages.
Other fourth quarter financial highlights	Corporate and Others share-based compensation was a recovery in 2022 due to a decrease in share price and an expense for the comparative period in 2021 due to an increase in share price. Corporate and Others other expenses decreased from $112 million to $67 million. Other expenses were lower due to net foreign exchange gains in 2022 compared to net foreign exchange losses in 2021 and lower expenses related to asset retirement obligations and accrued environmental costs for our non-operating sites from the changes in our cost and discount rate estimates. This was partially offset by an employee special recognition award expense in 2022. Finance costs were lower in 2022 mainly due to the absence of a loss of $142 million on early extinguishment of a portion of our long-term debt in the comparative period in 2021. We had higher cash flows from operating activities in the fourth quarter of 2022 from a higher release of working capital in 2022 compared to the same period in 2021 slightly offset by lower net earnings. Higher capital expenditures and business acquisitions resulted in higher cash used in investing activities. The repurchase of common shares in the fourth quarter of 2022 led to a higher use of cash flows from financing activities.

Controls and Procedures

Disclosure Controls and Procedures

We maintain disclosure controls and procedures designed to provide reasonable assurance that information required to be disclosed by Nutrien in its annual filings, interim filings (as these terms are defined in National Instrument 52-109 – *Certification of Disclosure in Issuers' Annual and Interim Filings* ("NI 52-109")) and other reports filed or submitted by us under securities legislation is recorded, processed, summarized and reported within the required time periods. Our Chief Executive Officer and Chief Financial Officer, after evaluating the effectiveness of our disclosure controls and procedures as of the end of the period covered by the annual filings, being December 31, 2022, have concluded that, as of such date, our disclosure controls and procedures were effective in providing reasonable assurance that information required to be disclosed by Nutrien in its annual filings, interim filings or other reports filed or submitted by it under securities legislation is (a) recorded, processed, summarized and reported within the time periods specified in the securities legislation, and (b) accumulated and communicated to management, including our Chief Executive Officer and Chief Financial Officer, as appropriate, to allow timely decisions regarding required disclosure.

There are inherent limitations to the effectiveness of any system of disclosure controls and procedures, including the possibility of human error and the circumvention or overriding of the controls and procedures. Accordingly, even effective disclosure controls and procedures can only provide reasonable assurance of achieving their control objectives.

Internal Control Over Financial Reporting

Management is responsible for establishing and maintaining adequate internal control over financial reporting, as defined in Rules 13a-15(f) and 15d-15(f) under the Securities Exchange Act of 1934, as amended, and NI 52-109. Internal control over financial reporting is designed to provide reasonable assurance regarding the reliability of financial reporting and preparation of consolidated financial statements for external purposes in accordance with IFRS.

Under the supervision and with the participation of our management, including our Chief Executive Officer and Chief Financial Officer, we conducted an evaluation of the design and effectiveness of our internal control over financial reporting as of the end of the fiscal year covered by this report based on the framework issued by the Committee of Sponsoring Organizations of the Treadway Commission in Internal Control – Integrated Framework (2013). Based on this evaluation, our Chief Executive Officer and Chief Financial Officer concluded that, as at December 31, 2022, Nutrien Ltd. did maintain effective internal control over financial reporting. There have been no changes that have materially affected, or are reasonably likely to materially affect, our internal control over financial reporting.

The effectiveness of the Company's internal control over financial reporting as at December 31, 2022 was audited by KPMG LLP, as reflected in their report, which is included in this 2022 Annual Report.

Forward-Looking Statements

Certain statements and other information included in this document, including within the "2023 Outlook and Guidance" section, constitute "forward-looking information" or "forward-looking statements" (collectively, "forward-looking statements") under applicable securities laws (such statements are often accompanied by words such as "anticipate", "forecast", "expect", "believe", "may", "will", "should", "estimate", "intend", "plan" or other similar words). All statements in this document, other than those relating to historical information or current conditions, are forward-looking statements, including, but not limited to: Nutrien's business strategies, plans, prospects and opportunities; Nutrien's 2023 annual guidance, including our expectations regarding our adjusted net earnings per share, adjusted EBITDA (consolidated and by segment); expectations regarding our adjusted net debt to adjusted EBITDA leverage ratios; expectations regarding adjusted EBITDA growth; expectations regarding our growth and capital allocation intentions and strategies; capital spending and allocation expectations for 2023 and beyond; expectations regarding performance of our operating segments in 2023 and beyond, including our operating segment market outlooks and market conditions, and the anticipated supply and demand for our products and services, expected market and industry conditions with respect to crop nutrient application rates, planted acres, crop mix, prices and the impact of import and export volumes; expectations regarding our operating segment production and capacity, including the proposed increase in potash operational capacity and anticipated benefits in connection with the Phase 2 brownfield nitrogen expansion project and the timing thereof; expectations regarding global population growth and our initiatives to respond thereto through product development and innovative solutions; expectations concerning future product offerings, including the planned expansion of our digital platform to markets in Australia and South America; expectations regarding repurchases of our common shares and our planned dividend growth, including the timing thereof; expectations regarding the sufficiency of Nutrien's liquidity, including the sources thereof, to meet our anticipated capital expenditures and other cash requirements; the negotiation of sales contracts and the associated prices thereunder; expectations regarding acquisitions and divestitures; expected timing for the natural gas supply curtailments at our Trinidad facility; expectations regarding our sustainability, climate-change and ESG initiatives, including our GHG emissions reduction strategy and related programs and initiatives, as well as our various sustainability commitments and ESG performance goals, targets, commitments and aspirations as set out in our Feeding the Future Plan; our pursuit of opportunities relating to our low-carbon ammonia, including evaluation of the clean ammonia facility project at Geismar, LA, and other opportunities for reducing GHG emissions associated with ammonia production; the launching, scaling and implementation of our Carbon Program and the anticipated benefits to Nutrien and growers therefrom; our GHG emissions reduction target, including our plans with respect thereto and estimated capital expenditures required to achieve that target; initiatives to promote safe, sustainable and productive agriculture; our ability to successfully reclaim land and our asset retirement obligations, including the cost, timing and anticipated results of future reclamation expenditures; our ability to leverage farm-focused technology partnerships and investments to drive positive impact in industry and grower innovation and inclusion; our commitment to create new financial solutions to strengthen social, economic and environmental outcomes in agriculture; our equity, diversity and inclusion initiatives and expected timing thereof; expectations regarding contributions to pensions and post-retirement plans; our ability to implement changes to make our business processes more resilient to cyberattacks; and expectations in connection with our ability to deliver long-term returns to shareholders and other stakeholders, including integrated reporting initiatives. These forward-looking statements are subject to a number of assumptions, risks and uncertainties, many of which are beyond our control, which could cause actual results to differ materially from such forward-looking statements. As such, undue reliance should not be placed on these forward-looking statements.

All of the forward-looking statements are qualified by the assumptions that are stated or inherent in such forward-looking statements, including the assumptions referred to below and elsewhere in this document. Although we believe that these assumptions are reasonable, having regard to our experience and our perception of historical trends, the list of assumptions set forth below is not exhaustive of the factors that may affect any of the forward-looking statements and the reader should not place an undue reliance on these assumptions and such forward-looking statements. Current conditions, economic and otherwise, render assumptions, although reasonable when made, subject to greater uncertainty.

In respect of our GHG emissions reduction and other sustainability and climate-related initiatives and targets, we have made assumptions with respect to, among other things: that such target is achievable by deploying capital into nitrous oxide ("N_2O") abatement at our nitric acid production facilities, energy efficiency improvements, carbon capture, utilization and storage, the use of natural gas to generate electricity and waste heat recovery; our ability to successfully deploy capital and pursue other operational measures, including the successful application to our current and future operations of existing and new technologies; the successful implementation by us of proposed or potential plans in respect thereof; projected capital investment levels, the flexibility of our capital

spending plans and the associated sources of funding; our ability to otherwise implement all technology necessary to achieve our GHG emissions reduction and other sustainability and climate-related initiatives and targets; and the development, availability and performance of technology and technological innovations and associated expected future results.

Additional key assumptions that have been made in relation to the operation of our business as currently planned and our ability to achieve our business objectives include, among other things, assumptions with respect to our ability to successfully complete, integrate and realize the anticipated benefits of our already completed and future acquisitions and divestitures, and that we will be able to implement our standards, controls, procedures and policies in respect of any acquired businesses and realize the expected synergies; that future business, regulatory and industry conditions will be within the parameters expected by us, including with respect to prices, margins, demand, including demand for our products and services, supply, product availability, supplier agreements, product distribution agreements, availability and cost of labor and interest, exchange, inflation and effective tax rates; assumptions with respect to global economic conditions and the accuracy of our market outlook expectations for 2023 and in the future; assumptions with respect to our intention to complete share repurchases under our share repurchase program, including the funding and TSX approval thereof, existing and future market conditions, including with respect to the price of our common shares, and compliance with respect to applicable limitations under securities laws and regulations and stock exchange policies; our expectations regarding the impacts, direct and indirect, of the war between Ukraine and Russia and the COVID-19 pandemic on, among other things, global supply and demand, energy and commodity prices, global interest rates, supply chains and the global macroeconomic environment, including inflation; the adequacy of our cash generated from operations and our ability to access our credit facilities or capital markets for additional sources of financing; our ability to identify suitable candidates for acquisitions and divestitures and negotiate acceptable terms; our ability to maintain investment-grade ratings and achieve our performance targets; our ability to successfully negotiate sales and other contracts; our ability to successfully implement new initiatives and programs; and our ability to redeploy capital to generate higher returns for shareholders.

Events or circumstances could cause actual results to differ materially from those in the forward-looking statements.

With respect to our GHG emissions reduction and other sustainability and climate-related initiatives and targets, such events or circumstances include, but are not limited to: our ability to deploy sufficient capital to fund the necessary expenditures to implement the necessary operational changes to achieve these initiatives and targets; our ability to implement requisite operational changes; our ability to implement some or all of the technology necessary to efficiently and effectively achieve expected future results, including in respect of such GHG emissions reduction targets; the availability and commercial viability and scalability of emission reduction strategies and related technology and products; and the development and execution of implementing strategies to meet such GHG emissions reduction target.

With respect to our business generally and our ability to meet the other targets, commitments, goals, strategies and related milestones and schedules disclosed herein, such events or circumstances include, but are not limited to: general global economic, market and business conditions, including inflation; failure to complete announced and future acquisitions or divestitures at all or on the expected terms and within the expected timeline; climate-change and weather conditions, including impacts from regional flooding and/or drought conditions; crop planted acreage, yield and prices; the supply and demand and price levels for our products; governmental and regulatory requirements and actions by governmental authorities, including changes in government policy (including tariffs, trade restrictions and climate-change initiatives), government ownership requirements, changes in environmental, tax and other laws or regulations and the interpretation thereof; political risks, including civil unrest, actions by armed groups or conflict and malicious acts including terrorism; the occurrence of a major environmental or safety incident; innovation and cybersecurity risks related to our systems, including our costs of addressing or mitigating such risks; counterparty and sovereign risk; delays in completion of turnarounds at our major facilities; interruptions of or constraints in availability of key inputs, including natural gas and sulfur; any significant impairment of the carrying amount of certain assets; risks related to reputational loss; certain complications that may arise in our mining processes; the ability to attract, engage and retain skilled employees and strikes or other forms of work stoppages; the war between Ukraine and Russia and its potential impact on, among other things, global market conditions and supply and demand, energy and commodity prices; interest rates, supply chains and the global economy generally; and other risk factors detailed from time to time in Nutrien reports filed with the Canadian securities regulators and the Securities and Exchange Commission in the US.

The purpose of our expected adjusted net earnings per share and adjusted EBITDA (consolidated and by segment) guidance ranges, as well as our adjusted net earnings per share and adjusted EBITDA price and volume sensitivities ranges, are to assist readers in understanding our expected and targeted financial results, and this information may not be appropriate for other purposes.

The forward-looking statements in this document are made as of the date hereof and Nutrien disclaims any intention or obligation to update or revise any forward-looking statements in this document as a result of new information or future events, except as may be required under applicable Canadian securities legislation or applicable US federal securities laws.

Appendix A – Non-IFRS Financial Measures

We use both IFRS measures and certain non-IFRS financial measures to assess performance. Non-IFRS financial measures are financial measures disclosed by a company that (a) depict historical or expected future financial performance, financial position or cash flow of a company, (b) with respect to their composition, exclude amounts that are included in, or include amounts that are excluded from, the composition of the most directly comparable financial measure disclosed in the primary financial statements of the company, (c) are not disclosed in the financial statements of the company, and (d) are not a ratio, fraction, percentage or similar representation. Non-IFRS ratios are financial measures disclosed by a company that are in the form of a ratio, fraction, percentage or similar representation that has a non-IFRS financial measure as one or more of its components, and that are not disclosed in the financial statements of the company.

These non-IFRS financial measures and non-IFRS ratios are not standardized financial measures under IFRS and, therefore, are unlikely to be comparable to similar financial measures presented by other companies. Management believes these non-IFRS financial measures and non-IFRS ratios provide transparent and useful supplemental information to help investors evaluate our financial performance, financial condition and liquidity using the same measures as management. These non-IFRS financial measures and non-IFRS ratios should not be considered as a substitute for, or superior to, measures of financial performance prepared in accordance with IFRS.

The following section outlines our non-IFRS financial measures and non-IFRS ratios, their compositions, and why management uses each measure. It also includes reconciliations to the most directly comparable IFRS measures. Except as otherwise described herein, our non-IFRS financial measures and non-IFRS ratios are calculated on a consistent basis from period to period and are adjusted for specific items in each period, as applicable. As additional non-recurring or unusual items arise in the future, we generally exclude these items in our calculations.

Adjusted EBITDA (Consolidated)

Most directly comparable IFRS financial measure: Net earnings (loss).

Definition: Adjusted EBITDA is calculated as net earnings (loss) before finance costs, income taxes, depreciation and amortization, share-based compensation and certain foreign exchange gain/loss (net of related derivatives). We also adjust this measure for the following other income and expenses that are excluded when management evaluates the performance of our day-to-day operations: integration and restructuring related costs, impairment or reversal of impairment of assets, COVID-19 related expenses, gain or loss on disposal of certain businesses and investments, and IFRS adoption transition adjustments.

Why we use the measure and why it is useful to investors: It is not impacted by long-term investment and financing decisions, but rather focuses on the performance of our day-to-day operations. It provides a measure of our ability to service debt and to meet other payment obligations, and as a component of employee remuneration calculations.

(millions of US dollars)	2022	2021
Net earnings	7,687	3,179
Finance costs	563	613
Income tax expense	2,559	989
Depreciation and amortization	2,012	1,951
EBITDA [1]	12,821	6,732
Share-based compensation expense	63	198
Foreign exchange loss, net of related derivatives	31	39
Integration and restructuring related costs	46	43
(Reversal of) impairment of assets	(780)	33
COVID-19 related expenses [2]	8	45
Gain on disposal of investment	(19)	–
Cloud computing transition adjustment [3]	–	36
Adjusted EBITDA	12,170	7,126

1 EBITDA is calculated as net earnings (loss) before finance costs, income taxes, and depreciation and amortization.
2 COVID-19 related expenses primarily consist of increased cleaning and sanitization costs, the purchase of personal protective equipment, discretionary supplemental employee costs, and costs related to construction delays from access limitations and other government restrictions.
3 Cloud computing transition adjustment relates to cloud computing costs in prior years that no longer qualify for capitalization based on an agenda decision issued by the IFRS Interpretations Committee in April 2021.

Adjusted Net Earnings and Adjusted Net Earnings Per Share

Most directly comparable IFRS financial measure: Net earnings (loss) and net earnings (loss) per share.

Definition: Adjusted net earnings and related per share information are calculated as net earnings (loss) before share-based compensation and certain foreign exchange gain/loss (net of related derivatives), net of tax. We also adjust this measure for the following other income and expenses (net of tax) that are excluded when management evaluates the performance of our day-to-day operations: certain integration and restructuring related costs, impairment or reversal of impairment of assets, COVID-19 related expenses (including those recorded under finance costs), gain or loss on disposal of certain businesses and investments, IFRS adoption transition adjustments, and gain/loss on early extinguishment of debt or on settlement of derivatives due to discontinuance of hedge accounting. In 2022, we amended our calculation of adjusted net earnings to adjust for a gain on settlement of a derivative due to discontinued hedge accounting. There was no similar gain or loss in the comparative period. We generally apply the annual forecasted effective tax rate to our adjustments during the year and, at year-end, we apply the actual effective tax rate. If the effective tax rate is significantly different from our forecasted effective tax rate due to adjustments or discrete tax impacts, we apply a tax rate that excludes those items. For material adjustments, we apply a tax rate specific to the adjustment.

Why we use the measure and why it is useful to investors: Focuses on the performance of our day-to-day operations and is used as a component of employee remuneration calculations.

	2022			2021		
(millions of US dollars, except as otherwise noted)	Increases (Decreases)	Post-Tax	Per Diluted Share	Increases (Decreases)	Post-Tax	Per Diluted Share
Net earnings attributable to equity holders of Nutrien		7,660	14.18		3,153	5.52
Adjustments:						
Share-based compensation expense	63	47	0.10	198	151	0.27
Foreign exchange loss, net of related derivatives	31	23	0.05	39	30	0.05
Integration and restructuring related costs	46	35	0.06	43	33	0.06
(Reversal of) impairment of assets	(780)	(619)	(1.15)	33	25	0.04
COVID-19 related expenses	8	6	0.01	45	34	0.06
Gain on disposal of investment	(19)	(14)	(0.03)	–	–	–
Gain on settlement of discontinued hedge accounting derivative	(18)	(14)	(0.03)	–	–	–
Cloud computing transition adjustment	–	–	–	36	27	0.05
Loss on early extinguishment of debt	–	–	–	142	104	0.18
Adjusted net earnings		7,124	13.19		3,557	6.23

Adjusted EBITDA (Consolidated) and Adjusted Net Earnings Per Share Guidance

Adjusted EBITDA and adjusted net earnings per share guidance are forward-looking non-IFRS financial measures. We do not provide a reconciliation of such forward-looking measures to the most directly comparable financial measures calculated and presented in accordance with IFRS because a meaningful or accurate calculation of reconciling items and the information is not available without unreasonable effort due to unknown variables, including the timing and amount of certain reconciling items, and the uncertainty related to future results. These unknown variables may include unpredictable transactions of significant value that may be inherently difficult to determine without unreasonable efforts. The probable significance of such unavailable information, which could be material to future results, cannot be addressed. Guidance for adjusted EBITDA and adjusted net earnings per share excludes certain items such as, but not limited to, the impacts of share-based compensation, certain foreign exchange gain/loss (net of related derivatives), integration and restructuring related costs, impairment or reversal of impairment of assets, COVID-19 related expenses (including those recorded under finance costs), gain or loss on disposal of certain businesses and investments, IFRS adoption transition adjustments, and gain/loss on early extinguishment of debt or on settlement of derivatives due to discontinuance of hedge accounting.

Growth Capital and Growth Capital Allocation

Most directly comparable IFRS financial measure: Cash used in investing activities.

Definition: Cash used in investing activities related to growth initiatives consisting of investing capital expenditures, which are a component of capital expenditures, plus business acquisitions, net of cash acquired per the consolidated statements of cash flows. Growth Capital Allocation allocates growth capital as a percentage by operating segments or a combination of operating segments.

Why we use the measure and why it is useful to investors: To demonstrate how we allocate our capital to our various priorities including growth and expansion projects and acquisitions.

(millions of US dollars)	2022	2021
Cash used in investing activities	(2,901)	(1,807)
Sustaining capital expenditures	1,449	1,247
Mine development and pre-stripping capital expenditures	234	156
Borrowing costs on property, plant and equipment	(37)	(29)
Other [1]	12	(64)
Net changes in non-cash working capital [1]	44	(101)
Growth capital	(1,199)	(598)

1 Included in investing activities as per the consolidated statement of cash flows.

Gross Margin Excluding Depreciation and Amortization Per Tonne – Manufactured

Most directly comparable IFRS financial measure: Gross margin.

Definition: Gross margin per tonne less depreciation and amortization per tonne for manufactured products. Reconciliations are provided in the “Our Results and Outlook – Operating Segment Performance” section.

Why we use the measure and why it is useful to investors: Focuses on the performance of our day-to-day operations, which excludes the effects of items that primarily reflect the impact of long-term investment and financing decisions.

Potash Controllable Cash Cost of Product Manufactured ("COPM") Per Tonne

Most directly comparable IFRS financial measure: Cost of goods sold ("COGS") for the Potash segment.

Definition: Total Potash COGS excluding depreciation and amortization expense included in COPM, royalties, natural gas costs and carbon taxes, change in inventory, and other adjustments, divided by potash production tonnes.

Why we use the measure and why it is useful to investors: To assess operational performance. In 2022, we replaced Potash cash COPM with this new financial measure. Potash controllable cash COPM excludes the effects of production from other periods and the impacts of our long-term investment decisions. Potash controllable cash COPM also excludes royalties and natural gas costs and carbon taxes, which management does not consider controllable, as they are primarily driven by regulatory and market conditions.

(millions of US dollars, except as otherwise noted)	2022	2021
Total COGS – Potash	1,400	1,285
Change in inventory	58	22
Other adjustments [1]	(41)	(6)
COPM	1,417	1,301
Depreciation and amortization in COPM	(406)	(430)
Royalties in COPM	(190)	(107)
Natural gas costs and carbon taxes in COPM	(62)	(51)
Controllable cash COPM	759	713
Production tonnes (tonnes – thousands)	13,007	13,790
Potash controllable cash COPM per tonne	58	52

1 Other adjustments include unallocated production overhead that is recognized as part of cost of goods sold but is not included in the measurement of inventory and changes in inventory balances.

Ammonia Controllable Cash COPM Per Tonne

Most directly comparable IFRS financial measure: Total manufactured COGS for the Nitrogen segment.

Definition: Total Nitrogen COGS excluding depreciation and amortization expense included in COGS, cash COGS for products other than ammonia, other adjustments, and natural gas and steam costs, divided by net ammonia production tonnes.

Why we use the measure and why it is useful to investors: To assess operational performance. Ammonia controllable cash COPM excludes the effects of production from other periods, the costs of natural gas and steam, and long-term investment decisions, supporting a focus on the performance of our day-to-day operations.

(millions of US dollars, except as otherwise noted)	2022	2021
Total Manufactured COGS – Nitrogen	3,197	2,353
Total Other COGS – Nitrogen	1,055	610
Total COGS – Nitrogen	4,252	2,963
Depreciation and amortization in COGS	(465)	(473)
Cash COGS for products other than ammonia	(2,560)	(1,740)
Ammonia		
Total cash COGS before other adjustments	1,227	750
Other adjustments [1]	(210)	(96)
Total cash COPM	1,017	654
Natural gas and steam costs in COPM	(855)	(515)
Controllable cash COPM	162	139
Production tonnes (net tonnes [2] – thousands)	2,754	2,769
Ammonia controllable cash COPM per tonne	59	50

1 Other adjustments include unallocated production overhead that is recognized as part of cost of goods sold but is not included in the measurement of inventory and changes in inventory balances.
2 Ammonia tonnes available for sale, as not upgraded to other Nitrogen products.

Retail Adjusted Average Working Capital to Sales and Retail Adjusted Average Working Capital to Sales Excluding Nutrien Financial

Definition: Retail adjusted average working capital divided by Retail adjusted sales for the last four rolling quarters. We exclude in our calculations the sales and working capital of certain acquisitions during the first year following the acquisition. We also look at this metric excluding Nutrien Financial revenue and working capital.

Why we use the measure and why it is useful to investors: To evaluate operational efficiency. A lower or higher percentage represents increased or decreased efficiency, respectively. The metric excluding Nutrien Financial shows the impact that the working capital of Nutrien Financial has on the ratio.

(millions of US dollars, except as otherwise noted)	2022	2021
Average current assets	11,952	9,332
Average current liabilities	(8,249)	(7,093)
Average working capital	3,703	2,239
Average working capital from certain recent acquisitions	–	–
Adjusted average working capital	3,703	2,239
Average Nutrien Financial working capital	(3,311)	(2,316)
Adjusted average working capital excluding Nutrien Financial	392	(77)
Sales	21,350	17,734
Sales from certain recent acquisitions	–	–
Adjusted sales	21,350	17,734
Nutrien Financial revenue	(267)	(189)
Adjusted sales excluding Nutrien Financial	21,083	17,545
Adjusted average working capital to sales (%)	17	13
Adjusted average working capital to sales excluding Nutrien Financial (%)	2	–

Nutrien Financial Adjusted Net Interest Margin

Definition: Nutrien Financial revenue less deemed interest expense divided by average Nutrien Financial receivables outstanding for the last four rolling quarters.

Why we use the measure and why it is useful to investors: Used by credit rating agencies and other users to evaluate the financial performance of Nutrien Financial.

(millions of US dollars, except as otherwise noted)	2022	2021
Nutrien Financial revenue	267	189
Deemed interest expense [1]	(41)	(36)
Net interest	226	153
Average Nutrien Financial receivables	3,311	2,316
Nutrien Financial adjusted net interest margin (%)	6.8	6.6

1 Average borrowing rate applied to the notional debt required to fund the portfolio of receivables from customers monitored and serviced by Nutrien Financial.

Retail Cash Operating Coverage Ratio

Definition: Retail selling, general and administrative, and other expenses, excluding depreciation and amortization expense, divided by Retail gross margin excluding depreciation and amortization expense in cost of goods sold, for the last four rolling quarters.

Why we use the measure and why it is useful to investors: To understand the costs and underlying economics of our Retail operations and to assess our Retail operating performance and ability to generate free cash flow.

(millions of US dollars, except as otherwise noted)	2022	2021
Selling expenses	3,392	3,124
General and administrative expenses	200	168
Other expenses	29	86
Operating expenses	3,621	3,378
Depreciation and amortization in operating expenses	(740)	(694)
Operating expenses excluding depreciation and amortization	2,881	2,684
Gross margin	5,179	4,600
Depreciation and amortization in cost of goods sold	12	12
Gross margin excluding depreciation and amortization	5,191	4,612
Cash operating coverage ratio (%)	55	58

Retail Normalized Comparable Store Sales

Most directly comparable IFRS financial measure: Retail sales from comparable base as a component of total Retail sales.

Definition: Prior year comparable store sales adjusted for average selling price (which generally moves with published potash, nitrogen and phosphate benchmark prices), acquisitions of new stores and foreign exchange rates used in the current year.

Why we use the measure and why it is useful to investors: To evaluate sales growth by adjusting for fluctuations in commodity prices and foreign exchange rates. Includes locations we have owned for more than 12 months.

(millions of US dollars, except as otherwise noted)	2022	2021
Sales from comparable base		
Prior period	17,734	14,785
Adjustments [1]	(64)	(476)
Revised prior period	17,670	14,309
Current period	21,092	17,511
Comparable store sales (%)	19	22
Prior period normalized for average selling prices and foreign exchange rates	21,867	16,350
Normalized comparable store sales (%)	(4)	7

1 Adjustments relate to prior period sales related to closed locations or businesses that no longer exist in the current period in order to provide a comparable base in our calculation.

Return on Invested Capital ("ROIC")

Definition: ROIC is calculated as net operating profit after taxes divided by the average invested capital for the last four rolling quarters.

Net operating profit after taxes, a non-IFRS financial measure, is calculated as earnings before finance costs and income taxes, depreciation and amortization related to the fair value adjustments as a result of the Merger (the merger of equals transaction between PotashCorp and Agrium), share-based compensation and certain foreign exchange gain/loss (net of related derivatives) and Nutrien Financial revenue. The most directly comparable IFRS financial measure to net operating profit after taxes is earnings before finance costs and income taxes. We also adjust this measure for the following other income and expenses that are excluded when management evaluates the performance of our day-to-day operations: integration and restructuring related costs, impairment or reversal of impairment of assets, COVID-19 related expenses, gain or loss on disposal of certain businesses and investments, and IFRS adoption transition adjustments. A tax rate of 25 percent is applied on the calculated amount.

Invested capital is calculated as last four rolling quarter average of total assets less cash and cash equivalents; payables and accrued charges; Merger fair value adjustments on goodwill, intangible assets, and property, plant and equipment; and average Nutrien Financial working capital.

We exclude in our calculations the related financial information of certain acquisitions during the first year following the acquisition.

Why we use the measure and why it is useful to investors: In 2022 we added a new financial measure to evaluate how efficiently we allocate our capital. ROIC provides useful information to evaluate our after-tax cash operating return on invested capital and is used as a component of employee remuneration calculations.

(millions of US dollars, except as otherwise noted)	**2022**	2021	2020
Earnings before finance costs and income taxes	**10,809**	4,781	902
Merger adjustments [1]	**231**	277	297
Integration and restructuring related costs	**46**	43	60
Share-based compensation	**63**	198	69
(Reversal of) impairment of assets	**(780)**	33	824
COVID-19 related expenses	**8**	45	48
Foreign exchange loss, net of related derivatives	**31**	39	19
(Gain) loss on disposal of business	**–**	–	6
Gain on disposal of investment	**(19)**	–	(250)
Cloud computing transition adjustment	**–**	36	–
Nutrien Financial revenue	**(267)**	(189)	(129)
Net operating profit	**10,122**	5,263	1,846
Tax (calculated at 25%)	**2,531**	1,316	462
Net operating profit after tax	**7,591**	3,947	1,384

1 Depreciation and amortization related to the fair value adjustments as a result of the Merger (the merger of equals transaction between PotashCorp and Agrium).

Total assets	**54,228**	48,880	47,533
Cash and cash equivalents	**(753)**	(862)	(1,629)
Payables and accrued charges	**(10,687)**	(8,773)	(6,991)
Merger adjustments [1]	**(10,232)**	(10,516)	(10,668)
Average Nutrien Financial receivables	**(3,311)**	(2,316)	(1,502)
Invested capital	**29,245**	26,413	26,743

1 Merger fair value adjustments on goodwill, intangible assets, and property, plant and equipment.

Return on invested capital (%)	**26**	15	5

Appendix B – Other Financial Measures

Supplementary Financial Measures

Supplementary financial measures are financial measures disclosed by a company that (a) are, or are intended to be, disclosed on a periodic basis to depict the historical or expected future financial performance, financial position or cash flow of a company, (b) are not disclosed in the financial statements of the company, (c) are not non-IFRS financial measures, and (d) are not non-IFRS ratios.

The following section provides an explanation of the composition of those supplementary financial measures if not previously provided.

Retail adjusted EBITDA margin: Retail adjusted EBITDA divided by Retail sales for the last four rolling quarters.

Retail digital platform sales: Grower and employee Retail sales in North America entered directly into the digital platform.

Retail digital platform sales to total sales: Grower and employee Retail sales in North America entered directly into the digital platform as a percentage of total Retail sales in North America.

Sustaining capital expenditures: Represents capital expenditures that are required to sustain operations at existing levels and include major repairs and maintenance and plant turnarounds.

Investing capital expenditures: Represents capital expenditures related to significant expansions of current operations or to create cost savings (synergies). Investing capital expenditures excludes capital outlays for business acquisitions and equity-accounted investees.

Mine development and pre-stripping capital expenditures: Represents capital expenditures that are required for activities to open new areas underground and/or develop a mine or ore body to allow for future production mining and activities required to prepare and/or access the ore, i.e., removal of an overburden that allows access to the ore.

Retail adjusted EBITDA per US selling location: Calculated as total Retail US adjusted EBITDA for the last four rolling quarters, representing the organic EBITDA component, which excludes acquisitions in those quarters, divided by the number of US locations that have generated sales in the last four rolling quarters, adjusted for acquired locations in those quarters.

Cash used for dividends and share repurchases (shareholder returns): Calculated as dividends paid to Nutrien's shareholders plus repurchase of common shares per the consolidated statements of cash flows. This measure is useful as it represents return of capital to shareholders.

Capital Management Measures

Capital management measures are financial measures disclosed by a company that (a) are intended to enable an individual to evaluate a company's objectives, policies and processes for managing the Company's capital, (b) are not a component of a line item disclosed in the primary financial statements of the company, (c) are disclosed in the notes of the financial statements of the company, and (d) are not disclosed in the primary financial statements of the company.

The following section outlines our capital management measure, its composition and why management uses the measure.

Adjusted net debt to adjusted EBITDA: Calculated as adjusted net debt to adjusted EBITDA. Both components are non-IFRS financial measures. This ratio measures financial leverage and our ability to pay our debt.

The most directly comparable measure for adjusted net debt is total short-term and long-term debt and lease liabilities less cash and cash equivalents and is defined as the total of short-term and long-term debt plus lease liabilities less cash and cash equivalents and unamortized fair value adjustments. This measure is useful as it adjusts for the unamortized fair value adjustments that arose at the time of the Merger and is non-cash in nature.

(millions of US dollars, except as otherwise noted)	2022	2021
Short-term debt	2,142	1,560
Current portion of long-term debt	542	545
Current portion of lease liabilities	305	286
Long-term debt	8,040	7,521
Lease liabilities	899	934
Total debt	11,928	10,846
Cash and cash equivalents	(901)	(499)
Unamortized fair value adjustments	(310)	(325)
Adjusted net debt	10,717	10,022

Five-Year Highlights

The following information is not part of our MD&A on SEDAR and EDGAR and is furnished for those readers who may find value in the use of such information over the long term. In future years, we plan to expand the historical data in these tables as the information becomes available.

Summary Financial Information

(millions of US dollars, except as otherwise noted)	2022	2021	2020	2019	2018
Operations					
Sales [1]	**37,884**	27,712	20,908	20,084	19,636
Earnings before finance costs and income taxes	**10,809**	4,781	902	1,862	414
Net earnings (loss) from continuing operations	**7,687**	3,179	459	992	(31)
Net earnings	**7,687**	3,179	459	992	3,573
Diluted net earnings (loss) per share from continuing operations (US dollars)	**14.18**	5.52	0.81	1.70	(0.05)
Diluted net earnings per share (US dollars)	**14.18**	5.52	0.81	1.70	5.72
Finance costs	**563**	613	520	554	538
Adjusted EBITDA [2]	**12,170**	7,126	3,667	4,025	3,934
Cash provided by operating activities	**8,110**	3,886	3,323	3,665	2,052
Balance Sheet					
Total assets	**54,586**	49,954	47,192	46,799	45,502
Short-term debt and long-term debt (including leases)	**11,928**	10,846	11,360	11,104	9,223
Total shareholders' equity	**25,863**	23,699	22,403	22,907	24,425
Common Share Information					
Weighted average common shares (millions)	**540**	571	570	583	625
Closing share price on NYSE (USD)	**73.03**	75.20	48.16	47.91	47.00
Total shareholder return percentage (%)	**(0.7)**	60.8	5.5	5.5	(6.6)
Operating Segment Information					
Retail net sales [1,3]	**21,350**	17,734	14,785	13,282	12,520
Potash net sales	**7,899**	4,036	2,146	2,604	2,667
Nitrogen net sales [4]	**7,533**	4,689	2,740	2,848	2,965
Phosphate net sales [4]	**2,377**	1,829	1,202	1,368	1,561
Retail adjusted EBITDA	**2,293**	1,939	1,430	1,231	1,206
Potash adjusted EBITDA	**5,769**	2,736	1,190	1,593	1,606
Nitrogen adjusted EBITDA [4]	**3,931**	2,308	1,080	1,239	1,215
Phosphate adjusted EBITDA [4]	**594**	540	232	194	255
Capital Allocation					
Sustaining capital expenditures [5]	**1,449**	1,247	919	1,018	985
Investing capital expenditures [5]	**792**	510	511	772	320
Mine development and pre-stripping expenditures [5]	**234**	156	109	96	100
Business acquisitions (net of cash acquired)	**407**	88	233	911	433
Dividends paid to Nutrien's shareholders	**1,031**	1,045	1,030	1,022	952
Repurchase of common shares	**4,520**	1,035	160	1,930	1,800

1 Certain immaterial figures have been reclassified for 2019 and 2018.
2 This is a non-IFRS financial measure. See the "Non-IFRS Financial Measures" section. Additional information relating to 2020, 2019 and 2018 is contained in the "Appendix – Non-IFRS Financial Measures" sections of Nutrien's MD&A dated February 17, 2021 for the year ended December 31, 2020, its MD&A dated February 19, 2020 for the year ended December 31, 2019 and its MD&A dated February 20, 2019 for the year ended December 31, 2018, respectively, which information is incorporated by reference herein. Such MD&A are available on SEDAR at www.sedar.com.
3 Certain immaterial figures have been reclassified or grouped together for 2018.
4 Restated 2018 for the reclassification of sulfate from the Phosphate segment to the Nitrogen segment.
5 These are supplementary financial measures. See the "Other Financial Measures" section.

Summary Non-Financial Information

	2022	2021	2020	2019	2018
Safety					
Total recordable injury frequency [1]	1.16	1.11	1.13	1.29	1.38
Lost-time injury frequency [1]	0.24	0.27	0.26	0.31	0.37
Serious injury and fatality incidents	5	-	1	1	2
Environment					
Environmental incidents [1]	35	24	23	24	20
Community					
Community investment ($ millions)	33	19	18	17	17
Employees					
Employees at December 31	24,700	23,500	23,100	22,300	20,300
Total employee turnover rate (%)	12	15	13	13	14
Proportion of women (%)	21	20	20	19	17
Proportion of women in senior leadership (director level and above) (%)	21	21	19	15	17

1 Restated 2018 to 2020 as a result of changes to classification of incidents.

Summary Production and Sales Volumes Information

	2022	2021	2020	2019	2018
Production (thousands)					
Potash production (product tonnes)	13,007	13,790	12,595	11,700	12,842
Nitrogen production (total ammonia tonnes) [1]	5,759	5,996	6,063	6,164	6,372
Phosphate production (P_2O_5 tonnes) [2]	1,351	1,518	1,444	1,514	1,551
Sales of manufactured product tonnes (thousands)					
Retail crop nutrient tonnes sold	11,513	13,383	12,732	11,048	10,689
Potash tonnes sold	12,537	13,625	12,824	11,521	13,019
Nitrogen tonnes sold [3]	10,023	10,725	10,966	10,270	10,598
Phosphate tonnes sold [3]	2,378	2,619	2,781	2,889	3,272

1 All figures are provided on a gross production basis.
2 Excludes Redwater. 2018 figures were restated to exclude Redwater.
3 Restated 2018 for the reclassification of sulfate from the Phosphate segment.


Nutrien
Soluções Agrícolas™

Financial Statements & Notes

Management's Responsibility

Management's Responsibility for Financial Reporting

Management's Report on the Consolidated Financial Statements

The accompanying consolidated financial statements and related financial information are the responsibility of the management of Nutrien Ltd. (the "Company"). They have been prepared in accordance with International Financial Reporting Standards ("IFRS") as issued by the International Accounting Standards Board and include amounts based on estimates and judgments. Financial information included elsewhere in this report is consistent with the consolidated financial statements.

The consolidated financial statements are approved by the Board of Directors on the recommendation of the Audit Committee. The Audit Committee, appointed by the Board of Directors, is composed entirely of independent directors. The Audit Committee discusses and analyzes the Company's condensed consolidated financial statements and Management's Discussion and Analysis ("MD&A") with management before such information is approved by the committee and submitted to securities commissions or other regulatory authorities. The Audit Committee and management also analyze the annual consolidated financial statements and MD&A prior to their approval by the Board of Directors.

The Audit Committee's duties also include reviewing critical accounting policies and significant estimates and judgments underlying the consolidated financial statements as presented by management and approving the fees of our independent registered public accounting firm.

Our independent registered public accounting firm, KPMG LLP, performs an audit of the consolidated financial statements, the results of which are reflected in their Report of Independent Registered Public Accounting Firm for 2022. KPMG LLP has full and independent access to the Audit Committee to discuss their audit and related matters.

Management's Annual Report on Internal Control Over Financial Reporting

Management is responsible for establishing and maintaining adequate internal control over financial reporting, as defined in Rules 13a-15(f) and 15d-15(f) of the Securities Exchange Act of 1934, as amended, and National Instrument 52-109 – *Certification of Disclosure in Issuers' Annual and Interim Filings*. Internal control over financial reporting is designed to provide reasonable assurance regarding the reliability of financial reporting and preparation of financial statements for external purposes in accordance with IFRS.

Under our supervision and with the participation of management, the Company conducted an evaluation of the design and effectiveness of our internal control over financial reporting as of the end of the fiscal year covered by this report, based on the framework issued by the Committee of Sponsoring Organizations of the Treadway Commission in Internal Control – Integrated Framework (2013). Based on this evaluation, management concluded that, as of December 31, 2022, the Company did maintain effective internal control over financial reporting.

The effectiveness of the Company's internal control over financial reporting as at December 31, 2022 has been audited by KPMG LLP, as reflected in their Report of Independent Registered Public Accounting Firm for 2022.

Ken Seitz
President and Chief Executive Officer
February 16, 2023

Pedro Farah
Executive Vice President and Chief Financial Officer
February 16, 2023

Report of Independent Registered Public Accounting Firm

To the Shareholders and Board of Directors of Nutrien Ltd.

Opinion on Internal Control Over Financial Reporting

We have audited Nutrien Ltd. and subsidiaries' (the "Company") internal control over financial reporting as of December 31, 2022, based on criteria established in Internal Control – Integrated Framework (2013) issued by the Committee of Sponsoring Organizations of the Treadway Commission. In our opinion, the Company maintained, in all material respects, effective internal control over financial reporting as of December 31, 2022, based on criteria established in Internal Control – Integrated Framework (2013) issued by the Committee of Sponsoring Organizations of the Treadway Commission.

We also have audited, in accordance with the standards of the Public Company Accounting Oversight Board (United States) ("PCAOB"), the consolidated balance sheets of the Company as of December 31, 2022 and 2021, the related consolidated statements of earnings, comprehensive income, cash flows, and changes in shareholders' equity for the years then ended, and the related notes (collectively, the "consolidated financial statements"), and our report dated February 16, 2023 expressed an unqualified opinion on those consolidated financial statements.

Basis for Opinion

The Company's management is responsible for maintaining effective internal control over financial reporting and for its assessment of the effectiveness of internal control over financial reporting, included in the accompanying Management's Annual Report on Internal Control Over Financial Reporting. Our responsibility is to express an opinion on the Company's internal control over financial reporting based on our audit. We are a public accounting firm registered with the PCAOB and are required to be independent with respect to the Company in accordance with the US federal securities laws and the applicable rules and regulations of the Securities and Exchange Commission and the PCAOB.

We conducted our audit in accordance with the standards of the PCAOB. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether effective internal control over financial reporting was maintained in all material respects. Our audit of internal control over financial reporting included obtaining an understanding of internal control over financial reporting, assessing the risk that a material weakness exists, and testing and evaluating the design and operating effectiveness of internal control based on the assessed risk. Our audit also included performing such other procedures as we considered necessary in the circumstances. We believe that our audit provides a reasonable basis for our opinion.

Definition and Limitations of Internal Control Over Financial Reporting

A company's internal control over financial reporting is a process designed to provide reasonable assurance regarding the reliability of financial reporting and the preparation of financial statements for external purposes in accordance with generally accepted accounting principles. A company's internal control over financial reporting includes those policies and procedures that (1) pertain to the maintenance of records that, in reasonable detail, accurately and fairly reflect the transactions and dispositions of the assets of the company; (2) provide reasonable assurance that transactions are recorded as necessary to permit preparation of financial statements in accordance with generally accepted accounting principles, and that receipts and expenditures of the company are being made only in accordance with authorizations of management and directors of the company; and (3) provide reasonable assurance regarding prevention or timely detection of unauthorized acquisition, use, or disposition of the company's assets that could have a material effect on the financial statements.

Because of its inherent limitations, internal control over financial reporting may not prevent or detect misstatements. Also, projections of any evaluation of effectiveness to future periods are subject to the risk that controls may become inadequate because of changes in conditions, or that the degree of compliance with the policies or procedures may deteriorate.

KPMG LLP

Chartered Professional Accountants

Calgary, Canada
February 16, 2023

Report of Independent Registered Public Accounting Firm

To the Shareholders and Board of Directors of Nutrien Ltd.

Opinion on the Consolidated Financial Statements

We have audited the accompanying consolidated balance sheets of Nutrien Ltd. and subsidiaries (the "Company") as of December 31, 2022 and 2021, the related consolidated statements of earnings, comprehensive income, cash flows, and changes in shareholders' equity for the years then ended, and the related notes (collectively, the "consolidated financial statements"). In our opinion, the consolidated financial statements present fairly, in all material respects, the financial position of the Company as of December 31, 2022 and 2021, and its financial performance and its cash flows for the years then ended, in conformity with International Financial Reporting Standards as issued by the International Accounting Standards Board.

We also have audited, in accordance with the standards of the Public Company Accounting Oversight Board (United States) ("PCAOB"), the Company's internal control over financial reporting as of December 31, 2022, based on criteria established in Internal Control – Integrated Framework (2013) issued by the Committee of Sponsoring Organizations of the Treadway Commission, and our report dated February 16, 2023 expressed an unqualified opinion on the effectiveness of the Company's internal control over financial reporting.

Basis for Opinion

These consolidated financial statements are the responsibility of the Company's management. Our responsibility is to express an opinion on these consolidated financial statements based on our audits. We are a public accounting firm registered with the PCAOB and are required to be independent with respect to the Company in accordance with the US federal securities laws and the applicable rules and regulations of the Securities and Exchange Commission and the PCAOB.

We conducted our audits in accordance with the standards of the PCAOB. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether the consolidated financial statements are free of material misstatement, whether due to error or fraud. Our audits included performing procedures to assess the risks of material misstatement of the consolidated financial statements, whether due to error or fraud, and performing procedures that respond to those risks. Such procedures included examining, on a test basis, evidence regarding the amounts and disclosures in the consolidated financial statements. Our audits also included evaluating the accounting principles used and significant estimates made by management, as well as evaluating the overall presentation of the consolidated financial statements. We believe that our audits provide a reasonable basis for our opinion.

Critical Audit Matters

The critical audit matters communicated below are matters arising from the current period audit of the consolidated financial statements that were communicated or required to be communicated to the Audit Committee and that: (1) relate to accounts or disclosures that are material to the consolidated financial statements and (2) involved our especially challenging, subjective, or complex judgments. The communication of critical audit matters does not alter in any way our opinion on the consolidated financial statements, taken as a whole, and we are not, by communicating the critical audit matters below, providing separate opinions on the critical audit matters or on the accounts or disclosures to which they relate.

Goodwill Impairment Assessment of the Retail North America Group of Cash-Generating Units

As discussed in Note 14 to the consolidated financial statements, the carrying amount of goodwill as of December 31, 2022 was $12,368 million, of which $6,898 million of goodwill has been allocated to the Retail North America group of cash-generating units ("Retail North America CGU"). The Retail North America CGU is tested for impairment annually, and whenever events or changes in circumstances may indicate the carrying amount, including goodwill, exceeds its estimated recoverable amount. An indicator of impairment was identified as of June 30, 2022 and September 30, 2022 due to an increase in benchmark borrowing rates, which is a component of the discount rate. The calculation of the recoverable amount of the Retail North America CGU involved estimates including forecasted earnings before tax, interest, depreciation and amortization ("EBITDA"), terminal growth rate and the discount rate.

We identified the calculation of the recoverable amount of goodwill for the Retail North America CGU as of September 30, 2022 as a critical audit matter. A high degree of auditor judgment was required to evaluate the Company's forecasted EBITDA, terminal growth rate and discount rate used to calculate the recoverable amount of the Retail North America CGU. Minor changes to these assumptions could have had a significant effect on the Company's calculation of the recoverable amount of the Retail North America CGU. Additionally, the audit effort associated with this estimate required specialized skills and knowledge.

The following are the primary procedures we performed to address this critical audit matter. We evaluated the design and tested the operating effectiveness of certain internal controls related to the calculation of the recoverable amount of goodwill for the Retail North America CGU. This included controls related to the determination of forecasted EBITDA, terminal growth rate and the discount rate. We evaluated the Company's forecasted EBITDA for the Retail North America CGU by comparing to historical results and forecasted planted acreage in the United States. We evaluated the terminal growth rate by comparing to the historical growth of the Retail North America CGU and to market information, including forecasted inflation and forecasted gross domestic product in the United States. We evaluated the Company's historical forecasts of EBITDA by comparing to actual results to assess the Company's ability to accurately forecast. In addition, we involved valuation professionals with specialized skills and knowledge, who assisted in:

- evaluating the Company's determination of the discount rate by comparing the inputs to the discount rate to publicly available market data for comparable entities and assessing the resulting discount rate, and
- evaluating the Company's estimate of the recoverable amount of the Retail North America CGU by comparing the results of the Company's estimate to publicly available market data and valuation metrics for comparable entities.

KPMG LLP

Chartered Professional Accountants

We have served as the Company's auditor since 2018.

Calgary, Canada
February 16, 2023

90 Nutrien Annual Report 2022 In millions of US dollars unless otherwise noted

Consolidated Financial Statements

Consolidated Statements of Earnings

For the years ended December 31	NOTE	2022	2021
Sales	3	37,884	27,712
Freight, transportation and distribution	4	872	851
Cost of goods sold	4, 12	21,588	17,452
Gross Margin		15,424	9,409
Selling expenses	4	3,414	3,142
General and administrative expenses	4	565	477
Provincial mining taxes	4	1,149	466
Share-based compensation expense	5	63	198
(Reversal of) impairment of assets	13	(780)	33
Other expenses	6	204	312
Earnings before finance costs and income taxes		10,809	4,781
Finance costs	7	563	613
Earnings before income taxes		10,246	4,168
Income tax expense	8	2,559	989
Net Earnings		7,687	3,179
Attributable to			
Equity holders of Nutrien		7,660	3,153
Non-controlling interest		27	26
Net Earnings		7,687	3,179
Net earnings per share attributable to equity holders of Nutrien (“EPS”)	9		
Basic		14.22	5.53
Diluted		14.18	5.52
Weighted average shares outstanding for basic EPS	9	538,475,000	569,664,000
Weighted average shares outstanding for diluted EPS	9	540,010,000	571,289,000

Consolidated Statements of Comprehensive Income

For the years ended December 31 (net of related income taxes)	NOTE	2022	2021
Net Earnings		7,687	3,179
Other comprehensive (loss) income			
Items that will not be reclassified to net earnings:			
Net actuarial gain on defined benefit plans	21	83	95
Net fair value (loss) gain on investments	15	(44)	81
Items that have been or may be subsequently reclassified to net earnings:			
Loss on currency translation of foreign operations		(199)	(115)
Other		(17)	17
Other Comprehensive (Loss) Income		(177)	78
Comprehensive Income		7,510	3,257
Attributable to			
Equity holders of Nutrien		7,484	3,232
Non-controlling interest		26	25
Comprehensive Income		7,510	3,257

(See Notes to the Consolidated Financial Statements)

In millions of US dollars unless otherwise noted

Consolidated Statements of Cash Flows

For the years ended December 31	NOTE	2022	2021
Operating activities			Note 2
Net earnings		7,687	3,179
Adjustments for:			
Depreciation and amortization		2,012	1,951
Share-based compensation expense	5	63	198
(Reversal of) impairment of assets	13	(780)	33
Gain on disposal of investment		(19)	–
Cloud computing transition adjustment	6	–	36
Loss on early extinguishment of debt		–	142
Provision for (recovery of) deferred income tax		182	(31)
Long-term income tax receivables	16	273	–
Net undistributed earnings of equity-accounted investees		(181)	(44)
Other long-term assets, liabilities and miscellaneous		21	83
Cash from operations before working capital changes		9,258	5,547
Changes in non-cash operating working capital:			
Receivables		(919)	(1,669)
Inventories		(1,281)	(1,459)
Prepaid expenses and other current assets		114	(227)
Payables and accrued charges		938	1,694
Cash provided by operating activities		8,110	3,886
Investing activities			
Capital expenditures [1]	13, 14	(2,438)	(1,884)
Business acquisitions, net of cash acquired	25	(407)	(88)
Other		(12)	64
Net changes in non-cash working capital		(44)	101
Cash used in investing activities		(2,901)	(1,807)
Financing activities			
Transaction costs related to debt		(9)	(7)
Proceeds from short-term debt, net	17, 18	529	1,344
Proceeds from long-term debt	18	1,045	86
Repayment of long-term debt	18	(561)	(2,212)
Repayment of principal portion of lease liabilities	18, 19	(341)	(320)
Dividends paid to Nutrien's shareholders	23	(1,031)	(1,045)
Repurchase of common shares	23	(4,520)	(1,035)
Issuance of common shares	23	168	200
Other		(11)	(14)
Cash used in financing activities		(4,731)	(3,003)
Effect of exchange rate changes on cash and cash equivalents		(76)	(31)
Increase (Decrease) in cash and cash equivalents		402	(955)
Cash and cash equivalents – beginning of year		499	1,454
Cash and cash equivalents – end of year		901	499
Cash and cash equivalents is composed of:			
Cash		775	428
Short-term investments		126	71
		901	499
Supplemental cash flows information			
Interest paid		482	491
Income taxes paid		1,882	435
Total cash outflow for leases		459	393

1 Includes additions to property, plant and equipment, and intangible assets of $2,227 and $211 (2021 – $1,777 and $107), respectively.

(See Notes to the Consolidated Financial Statements)

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Consolidated Statements of Changes in Shareholders' Equity

	Number of Common Shares	Share Capital	Contributed Surplus	Accumulated Other Comprehensive (Loss) Income ("AOCI"): Loss on Currency Translation of Foreign Operations	AOCI: Other	AOCI: Total AOCI	Retained Earnings	Equity Holders of Nutrien	Non-Controlling Interest	Total Equity
Balance – December 31, 2020	569,260,406	15,673	205	(62)	(57)	(119)	6,606	22,365	38	22,403
Net earnings	–	–	–	–	–	–	3,153	3,153	26	3,179
Other comprehensive (loss) income	–	–	–	(114)	193	79	–	79	(1)	78
Shares repurchased (Note 23)	(15,982,154)	(442)	(47)	–	–	–	(616)	(1,105)	–	(1,105)
Dividends declared (Note 23)	–	–	–	–	–	–	(1,046)	(1,046)	–	(1,046)
Non-controlling interest transactions	–	–	–	–	–	–	–	–	(16)	(16)
Effect of share-based compensation including issuance of common shares	4,424,437	226	(9)	–	–	–	–	217	–	217
Transfer of net gain on cash flow hedges	–	–	–	–	(11)	(11)	–	(11)	–	(11)
Transfer of net actuarial gain on defined benefit plans	–	–	–	–	(95)	(95)	95	–	–	–
Share cancellation	(210,173)	–	–	–	–	–	–	–	–	–
Balance – December 31, 2021	557,492,516	15,457	149	(176)	30	(146)	8,192	23,652	47	23,699
Net earnings	–	–	–	–	–	–	7,660	7,660	27	7,687
Other comprehensive (loss) income	–	–	–	(198)	22	(176)	–	(176)	(1)	(177)
Shares repurchased (Note 23)	(53,312,559)	(1,487)	(22)	–	–	–	(2,987)	(4,496)	–	(4,496)
Dividends declared (Note 23)	–	–	–	–	–	–	(1,019)	(1,019)	–	(1,019)
Non-controlling interest transactions	–	–	–	–	–	–	(1)	(1)	(28)	(29)
Effect of share-based compensation including issuance of common shares	3,066,148	202	(18)	–	–	–	–	184	–	184
Transfer of net loss on cash flow hedges	–	–	–	–	14	14	–	14	–	14
Transfer of net actuarial gain on defined benefit plans	–	–	–	–	(83)	(83)	83	–	–	–
Balance – December 31, 2022	507,246,105	14,172	109	(374)	(17)	(391)	11,928	25,818	45	25,863

(See Notes to the Consolidated Financial Statements)

In millions of US dollars unless otherwise noted Nutrien Annual Report 2022 93

Consolidated Balance Sheets

As at December 31	NOTE	2022	2021
Assets			
Current assets			
Cash and cash equivalents		901	499
Receivables	11	6,194	5,366
Inventories	12	7,632	6,328
Prepaid expenses and other current assets		1,615	1,653
		16,342	13,846
Non-current assets			
Property, plant and equipment	13	21,767	20,016
Goodwill	14	12,368	12,220
Intangible assets	14	2,297	2,340
Investments	15	843	703
Other assets	16	969	829
Total Assets		54,586	49,954
Liabilities			
Current liabilities			
Short-term debt	17	2,142	1,560
Current portion of long-term debt	18	542	545
Current portion of lease liabilities	19	305	286
Payables and accrued charges	20	11,291	10,052
		14,280	12,443
Non-current liabilities			
Long-term debt	18	8,040	7,521
Lease liabilities	19	899	934
Deferred income tax liabilities	8	3,547	3,165
Pension and other post-retirement benefit liabilities	21	319	419
Asset retirement obligations and accrued environmental costs	22	1,403	1,566
Other non-current liabilities		235	207
Total Liabilities		28,723	26,255
Shareholders' Equity			
Share capital	23	14,172	15,457
Contributed surplus		109	149
Accumulated other comprehensive loss		(391)	(146)
Retained earnings		11,928	8,192
Equity holders of Nutrien		25,818	23,652
Non-controlling interest		45	47
Total Shareholders' Equity		25,863	23,699
Total Liabilities and Shareholders' Equity		54,586	49,954

(See Notes to the Consolidated Financial Statements)

Approved by the Board of Directors,

Director

Christopher Burley

Director

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Note 1 Description of Business

Nutrien Ltd. (collectively with its subsidiaries, "Nutrien", "we", "us", "our" or "the Company") is the world's largest provider of crop inputs and services. Nutrien plays a critical role in helping growers around the globe increase food production in a sustainable manner.

The Company is a corporation organized under the laws of Canada with its registered head office located at Suite 1700, 211 19th Street East, Saskatoon, Saskatchewan, Canada, S7K 5R6. As at December 31, 2022, the Company had assets as follows:

Segment	Description
Nutrien Ag Solutions ("Retail")	• various retail facilities across the US, Canada, Australia and South America • private label and proprietary crop protection products and nutritionals • an innovative integrated digital platform for growers and crop consultants • a financing solutions provider in support of Nutrien's agricultural product and service sales
Potash	• 6 operations in the province of Saskatchewan
Nitrogen	• 8 production facilities in North America: 4 in Alberta, 1 in Georgia, 1 in Louisiana, 1 in Ohio and 1 in Texas • 1 large-scale operation in Trinidad • 5 upgrade facilities in North America: 3 in Alberta, 1 in Missouri and 1 in Washington • 50 percent investment in Profertil S.A. ("Profertil"), a nitrogen producer based in Argentina
Phosphate	• 2 mines and processing plants: 1 in Florida and 1 in North Carolina • phosphate feed plants in Illinois, Missouri and Nebraska • 1 industrial phosphoric acid plant in Ohio
Corporate and Others	• investment in Canpotex Limited ("Canpotex"), a Canadian potash export, sales and marketing company owned in equal shares by Nutrien and another potash producer • 22 percent investment in Sinofert Holdings Limited ("Sinofert"), a fertilizer supplier and distributor in China

Note 2 Basis of Presentation

We prepared these consolidated financial statements in accordance with International Financial Reporting Standards ("IFRS") as issued by the International Accounting Standards Board ("IASB"). We have consistently applied the same accounting policies throughout all periods presented, as if these policies had always been in effect, with the exception of the accounting standards adopted effective January 1, 2022, as disclosed in Note 30.

Certain immaterial 2021 figures have been reclassified in the consolidated statements of cash flows and segment information note.

These consolidated financial statements were authorized for issue by the Board of Directors on February 16, 2023.

Sensitivity analyses included throughout the notes should be used with caution as the changes are hypothetical and not reflective of future performance. The sensitivities have been calculated independently of changes in other key variables. Changes in one factor may result in changes in another, which could increase or reduce certain sensitivities. We prepared these consolidated financial statements under the historical cost basis, except for items that IFRS requires to be measured at fair value. Details of our accounting policies are primarily disclosed in Note 30. Reference to n/a indicates information is not applicable.

In millions of US dollars unless otherwise noted

Note 3 Segment Information

The Company has four reportable operating segments: Nutrien Ag Solutions ("Retail"), Potash, Nitrogen and Phosphate. The Retail segment distributes crop nutrients, crop protection products, seed and merchandise, and it provides services directly to growers through a network of farm centers in North America, South America and Australia. The Potash, Nitrogen and Phosphate segments are differentiated by the chemical nutrient contained in the products that each produces.

The Executive Leadership Team ("ELT"), composed of officers at the Executive Vice President level and above, is the Chief Operating Decision Maker ("CODM"). The CODM uses adjusted net earnings (loss) before finance costs, income taxes, and depreciation and amortization ("adjusted EBITDA") to measure performance and allocate resources to the operating segments. The CODM considers adjusted EBITDA to be a meaningful measure because it is not impacted by long-term investment and financing decisions, but rather focuses on the performance of our day-to-day operations. In addition, it excludes the impact of impairments and other costs that are centrally managed by our corporate function.

We determine the composition of the reportable segments based on factors including risks and returns, internal organization, and internal reports reviewed by the CODM. We allocate certain expenses across segments based on reasonable considerations such as production capacities or historical trends.

2022	Retail	Potash	Nitrogen	Phosphate	Corporate and Others	Eliminations	Consolidated
Sales – third party	21,266	7,600	6,755	2,263	–	–	37,884
– intersegment	84	599	1,293	357	–	(2,333)	–
Sales – total	21,350	8,199	8,048	2,620	–	(2,333)	37,884
Freight, transportation and distribution	–	300	515	243	–	(186)	872
Net sales	21,350	7,899	7,533	2,377	–	(2,147)	37,012
Cost of goods sold	16,171	1,400	4,252	1,884	–	(2,119)	21,588
Gross margin	5,179	6,499	3,281	493	–	(28)	15,424
Selling expenses	3,392	10	28	7	(1)	(22)	3,414
General and administrative expenses	200	9	17	13	326	–	565
Provincial mining taxes	–	1,149	–	–	–	–	1,149
Share-based compensation expense	–	–	–	–	63	–	63
Reversal of impairment of assets (Note 13)	–	–	–	(780)	–	–	(780)
Other expenses (income)	29	5	(137)	67	227	13	204
Earnings (loss) before finance costs and income taxes	1,558	5,326	3,373	1,186	(615)	(19)	10,809
Depreciation and amortization	752	443	558	188	71	–	2,012
EBITDA [1]	2,310	5,769	3,931	1,374	(544)	(19)	12,821
Integration and restructuring related costs	2	–	–	–	44	–	46
Share-based compensation expense	–	–	–	–	63	–	63
Reversal of impairment of assets (Note 13)	–	–	–	(780)	–	–	(780)
COVID-19 coronavirus pandemic ("COVID-19") related expenses	–	–	–	–	8	–	8
Foreign exchange loss, net of related derivatives	–	–	–	–	31	–	31
Gain on disposal of investment	(19)	–	–	–	–	–	(19)
Adjusted EBITDA	2,293	5,769	3,931	594	(398)	(19)	12,170
Assets	24,451	13,921	11,807	2,661	2,622	(876)	54,586

1 EBITDA is calculated as net earnings (loss) before finance costs, income taxes, and depreciation and amortization.

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2021	Retail	Potash	Nitrogen	Phosphate	Corporate and Others	Eliminations	Consolidated
Sales – third party	17,665	4,021	4,216	1,810	–	–	27,712
– intersegment	69	386	921	236	–	(1,612)	–
Sales – total	17,734	4,407	5,137	2,046	–	(1,612)	27,712
Freight, transportation and distribution	–	371	448	217	–	(185)	851
Net sales	17,734	4,036	4,689	1,829	–	(1,427)	26,861
Cost of goods sold	13,134	1,285	2,963	1,408	–	(1,338)	17,452
Gross margin	4,600	2,751	1,726	421	–	(89)	9,409
Selling expenses	3,124	9	24	6	(21)	–	3,142
General and administrative expenses	168	8	15	11	275	–	477
Provincial mining taxes	–	466	–	–	–	–	466
Share-based compensation expense	–	–	–	–	198	–	198
Impairment of assets (Note 13)	–	7	22	4	–	–	33
Other expenses (income)	86	22	(64)	15	253	–	312
Earnings (loss) before finance costs and income taxes	1,222	2,239	1,729	385	(705)	(89)	4,781
Depreciation and amortization	706	488	557	151	49	–	1,951
EBITDA	1,928	2,727	2,286	536	(656)	(89)	6,732
Integration and restructuring related costs	10	–	–	–	33	–	43
Share-based compensation expense	–	–	–	–	198	–	198
Impairment of assets (Note 13)	–	7	22	4	–	–	33
COVID-19 related expenses	–	–	–	–	45	–	45
Foreign exchange loss, net of related derivatives	–	–	–	–	39	–	39
Cloud computing transition adjustment (Note 6)	1	2	–	–	33	–	36
Adjusted EBITDA	1,939	2,736	2,308	540	(308)	(89)	7,126
Assets	22,387	13,148	11,093	1,699	2,266	(639)	49,954

Retail Segment Products	**Sales**
Crop nutrients	Dry and liquid macronutrient products including potash, nitrogen and phosphate, proprietary liquid micronutrient products, and nutrient application services.
Crop protection products	Various third-party supplier and proprietary products designed to maintain crop quality and manage plant diseases, weeds and other pests.
Seed	Various third-party supplier seed brands and proprietary seed product lines.
Merchandise	Fencing, feed supplements, livestock-related animal health products, storage and irrigation equipment, and other products.
Nutrien Financial	Financing solutions provided to Retail branches and customers in support of Nutrien's agricultural product and service sales.
Services and other revenues	Product application, soil and leaf testing, crop scouting and precision agriculture services, and water services.

In millions of US dollars unless otherwise noted

	Products	Sales Prices Impacted By
Potash	• North American – primarily granular • Offshore (international) – primarily granular and standard	• North American prices referenced at delivered prices (including transportation and distribution costs) • International prices pursuant to term and spot contract prices (excluding transportation and distribution costs)
Nitrogen	• Ammonia, urea, urea ammonium nitrate, industrial grade ammonium nitrate and ammonium sulfate	• Global energy costs and supply
Phosphate	• Solid fertilizer, liquid fertilizer, industrial products and feed products	• Global prices and supplies of ammonia and sulfur

	2022	2021
Retail sales by product line		
Crop nutrients	10,060	7,290
Crop protection products	7,067	6,333
Seed	2,112	2,008
Merchandise	1,019	1,033
Nutrien Financial	267	189
Services and other [1]	966	980
Nutrien Financial elimination [1,2]	(141)	(99)
	21,350	17,734
Potash sales by geography		
Manufactured product		
North America	2,785	2,009
Offshore [3]	5,414	2,398
	8,199	4,407
Nitrogen sales by product line		
Manufactured product		
Ammonia	2,834	1,556
Urea	2,037	1,568
Solutions, nitrates and sulfates	1,996	1,274
Other nitrogen and purchased products	1,181	739
	8,048	5,137
Phosphate sales by product line		
Manufactured product		
Fertilizer	1,520	1,250
Industrial and feed	763	574
Other phosphate and purchased products	337	222
	2,620	2,046

1 Certain immaterial 2021 figures have been reclassified.
2 Represents elimination for the interest and service fees charged by Nutrien Financial to Retail branches.
3 Relates to Canpotex (Note 28) and includes other revenue representing provisional pricing adjustments of $(105) (2021 – $282).

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	Sales – Third Party [1]		Non-Current Assets [2]	
	2022	2021	**2022**	2021
United States	**20,089**	16,009	**15,971**	15,095
Canada	**3,783**	3,094	**18,303**	17,766
Australia	**3,877**	3,591	**1,105**	1,202
Canpotex (Note 28)	**5,414**	2,398	**–**	–
Trinidad	**15**	258	**688**	638
Brazil	**1,136**	567	**851**	391
Other	**3,570** [3]	1,795 [3]	**521**	340
	37,884	27,712	**37,439**	35,432

1 Sales by location of customers.
2 Excludes financial instruments (other than equity-accounted investees), deferred tax assets and post-employment benefit assets.
3 Other third-party sales primarily relate to Argentina of $666 (2021 – $526), Europe of $856 (2021 – $236) and Others of $2,048 (2021 – $1,033).

Canpotex sales by market (%)	2022	2021
Latin America	**34**	38
Other Asian markets [1]	**34**	35
China	**14**	11
Other markets	**10**	10
India	**8**	6

1 All Asian markets except China and India.

Note 4 Nature of Expenses

	2022	2021
Purchased and produced raw materials and product for resale [1]	**18,747**	14,711
Depreciation and amortization	**2,012**	1,951
Employee costs [2]	**2,968**	3,007
Freight	**1,094**	1,023
(Reversal of) impairment of assets (Note 13)	**(780)**	33
Provincial mining taxes [3]	**1,149**	466
Integration and restructuring related costs	**46**	43
Contract services	**745**	590
Lease expense [4]	**93**	81
Fleet fuel, repairs and maintenance	**359**	302
Gain on disposal of investment	**(19)**	–
COVID-19 related expenses	**8**	45
Cloud computing transition adjustment	**–**	36
Other	**653**	643
Total cost of goods sold and expenses	**27,075**	22,931

1 Significant expenses include supplies, energy, fuel, purchases of raw material (natural gas – feedstock, sulfur, ammonia and reagents) and product for resale (crop nutrients and protection products, and seed).
2 Includes salaries and wages, employee benefits, and share-based compensation.
3 Includes Saskatchewan potash production tax, and Saskatchewan resource surcharge of $909 and $240 (2021 – $341 and $125), respectively, as required under Saskatchewan provincial legislation.
4 Includes lease expense relating to short-term leases, leases of low value and variable lease payments.

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Note 5 Share-based Compensation

Plans	Eligibility	Granted	Vesting Period	Maximum Term	Settlement
Stock Options	Officers and eligible employees	Annually	25 percent per year over four years	10 years	Shares [1]
Performance Share Units ("PSUs")	Officers and eligible employees	Annually	On third anniversary of grant date based on total shareholder return over a three-year performance cycle, compared to average total shareholder return of a peer group of companies over the same period	Not applicable	Cash
Restricted Share Units ("RSUs")	Officers and eligible employees	Annually	On third anniversary of grant date and not subject to performance conditions	Not applicable	Cash
Deferred Share Units ("DSUs")	Non-executive directors	At the discretion of the Board of Directors	Fully vest upon grant	Not applicable	Cash [2]
Stock Appreciation Rights ("SARs") / Tandem Stock Appreciation Rights ("TSARs") [3]	Awards no longer granted; legacy awards only	Awards no longer granted; legacy awards only	25 percent per year over four years	10 years	Cash

1 Stock options may also be settled by cash settlement or, if approved by the Company, by a broker-assisted "cashless exercise" arrangement or a "net exercise" arrangement.
2 Directors can redeem their DSUs for cash only when they leave the Board of Directors for an amount equal to the market value of the common shares at the time of redemption or as mandated by the Nutrien DSU Plan.
3 Holders of TSARs have the ability to choose between (a) receiving in cash the price of our shares on the date of exercise in excess of the exercise price of the right or (b) receiving common shares by paying the exercise price of the right. Our past experience and future expectation is that substantially all TSAR holders will elect to choose the first option.

The weighted average fair value of stock options granted was estimated as of the date of the grant using the Black-Scholes-Merton option-pricing model. The weighted average grant date fair value of stock options per unit granted in 2022 was $20.49 (2021 – $11.77). The weighted average assumptions by year of grant that impacted current year results are as follows:

		Year of Grant	
Assumptions	**Based On**	**2022**	2021
Exercise price per option	Quoted market closing price of common shares on the last trading day immediately preceding the date of the grant	77.50	56.64
Expected annual dividend yield (%)	Annualized dividend rate as of the date of the grant	2.45	3.22
Expected volatility (%)	Historical volatility of Nutrien's shares over a period commensurate with the expected life of the grant	30	29
Risk-free interest rate (%)	Zero-coupon government issues implied yield available on equivalent remaining term at the time of the grant	2.00	1.11
Average expected life of options (years)	Historical experience	8.5	8.5

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	Number of Shares Subject to Option		Weighted Average Exercise Price	
	2022	2021	**2022**	2021
Outstanding – beginning of year	**6,744,720**	10,997,892	**54.87**	53.59
Granted	**375,483**	1,518,490	**77.50**	56.62
Exercised	**(3,066,148)**	(4,336,682)	**54.37**	45.24
Forfeited or cancelled	**(66,219)**	(375,005)	**65.92**	50.34
Expired	**(102,358)**	(1,059,975)	**99.53**	85.66
Outstanding – end of year	**3,885,478**	6,744,720	**55.48**	54.87

The aggregate grant date fair value of all stock options granted in 2022 was $8. The average share price in 2022 was $86.22 per share.

The following table summarizes information about our stock options outstanding as at December 31, 2022, with expiry dates ranging from May 2023 to February 2032:

	Options Outstanding			Options Exercisable	
Range of Exercise Prices	**Number**	**Weighted Average Remaining Life in Years**	**Weighted Average Exercise Price**	**Number**	**Weighted Average Exercise Price**
$37.84 to $41.31	154,255	3	39.08	154,255	39.08
$41.32 to $43.36	1,084,241	5	42.23	194,063	42.23
$43.37 to $52.75	473,441	4	46.15	473,441	46.15
$52.76 to $55.08	487,590	4	53.54	234,175	53.54
$55.09 to $64.43	964,532	7	56.62	82,592	56.62
$64.44 to $109.45	721,419	5	84.78	375,420	91.49
	3,885,478	5	55.48	1,513,946	57.89

			Compensation Expense	
	Units Granted in 2022	**Units Outstanding as at December 31, 2022**	**2022**	2021
Stock options	375,483	3,885,478	11	14
PSUs	508,528	2,011,838	13	104
RSUs	497,766	1,483,868	33	47
DSUs	23,721	392,550	2	12
SARs/TSARs	–	228,172	4	21
			63	198

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Note 6 Other Expenses (Income)

	2022	2021
Integration and restructuring related costs	46	43
Foreign exchange loss, net of related derivatives	31	42
Earnings of equity-accounted investees	(247)	(89)
Bad debt expense	12	26
COVID-19 related expenses	8	45
Gain on disposal of investment	(19)	–
Project feasibility costs	79	50
Customer prepayment costs	42	45
Legal expenses	21	6
Consulting expenses	29	4
Employee special recognition award	61	–
Cloud computing transition adjustment	–	36
Other expenses	141	104
	204	312

In 2021, the IFRS Interpretations Committee published a final agenda decision that clarified how to recognize certain configuration and customization expenditures related to cloud computing with retrospective application. Costs that do not meet the capitalization criteria should be expensed as incurred. In 2021, we changed our accounting policy to align with the interpretation and previously capitalized costs that no longer qualified for capitalization were expensed as a transition adjustment since they were not material.

Note 7 Finance Costs

	2022	2021
Interest expense		
Short-term debt	153	44
Long-term debt	333	415
Lease liabilities	35	33
Total interest expense	521	492
Loss on early extinguishment of debt	–	142
Unwinding of discount on asset retirement obligations (Note 22)	29	(9)
Interest on net defined benefit pension and other post-retirement plan obligations (Note 21)	8	9
Borrowing costs capitalized to property, plant and equipment	(37)	(29)
Interest income	(25)	(8)
Other finance costs	67	16
	563	613

Borrowing costs capitalized to property, plant and equipment in 2022 were calculated by applying an average capitalization rate of 4.1 percent (2021 – 4.1 percent) to expenditures on qualifying assets.

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Note 8 Income Taxes

	2022	2021
Current income tax		
Tax expense for current year	2,314	1,033
Adjustments in respect of prior years	63	(13)
Total current income tax expense	2,377	1,020
Deferred income tax		
Origination and reversal of temporary differences	215	(30)
Adjustments in respect of prior years	(41)	6
Change in recognition of tax losses and deductible temporary differences	8	(6)
Impact of tax rate changes	–	(1)
Total deferred income tax expense (recovery)	182	(31)
Income tax expense included in net earnings	2,559	989

We operate in a specialized industry and in several tax jurisdictions; as a result, our earnings are subject to various rates of taxation.

The provision for income taxes differs from the amount that would have resulted from applying the Canadian statutory income tax rates to earnings before income taxes as follows:

	2022	2021
Earnings before income taxes		
Canada	5,707	1,884
United States	3,447	1,319
Trinidad	487	256
Australia	263	204
Other	342	505
	10,246	4,168
Canadian federal and provincial statutory income tax rate (%)	27	27
Income tax at statutory rates	2,766	1,125
Adjusted for the effect of:		
Impact of foreign tax rates	(132)	(98)
Non-taxable income	(98)	(18)
Production-related deductions	(51)	(24)
Withholding taxes	18	3
Non-deductible expenses	17	12
Other	39	(11)
Income tax expense included in net earnings	2,559	989

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Deferred Income Taxes

	Deferred Income Tax (Assets) Liabilities		Deferred Income Tax (Recovery) Expense Recognized in Net Earnings	
	2022	2021	**2022**	2021
Deferred income tax assets				
Tax loss and other carryforwards	**(396)**	(297)	**(93)**	75
Asset retirement obligations and accrued environmental costs	**(319)**	(354)	**35**	21
Lease liabilities	**(298)**	(151)	**(151)**	47
Inventories	**(155)**	(126)	**(30)**	(90)
Pension and other post-retirement benefit liabilities	**(151)**	(178)	**(1)**	(45)
Long-term debt	**(117)**	(140)	**21**	(39)
Payables and accrued charges	**(98)**	(14)	**(84)**	(14)
Receivables	**(48)**	(44)	**(4)**	6
Other assets	**(1)**	(1)	**–**	11
Deferred income tax liabilities				
Property, plant and equipment	**4,305**	3,765	**545**	132
Goodwill and intangible assets	**347**	404	**(53)**	(64)
Payables and accrued charges	**–**	–	**–**	(72)
Other liabilities	**30**	39	**(3)**	1
	3,099	2,903	**182**	(31)

Reconciliation of net deferred income tax liabilities:

	2022	2021
Balance – beginning of year	**2,903**	2,907
Income tax expense (recovery) recognized in net earnings	**182**	(31)
Income tax charge recognized in other comprehensive income ("OCI")	**7**	30
Other	**7**	(3)
Balance – end of year	**3,099**	2,903

Amounts and expiry dates of unused tax losses and unused tax credits as at December 31, 2022, were:

	Amount	**Expiry Date**
Unused federal operating losses	1,508	2026 – Indefinite
Unused federal capital losses	562	Indefinite

The unused tax losses and credits with no expiry dates can be carried forward indefinitely.

As at December 31, 2022, we had $778 of federal tax losses for which we did not recognize deferred tax assets.

We have determined that it is probable that all recognized deferred tax assets will be realized through a combination of future reversals of temporary differences and taxable income.

We did not recognize deferred tax liabilities related to temporary differences associated with investments in subsidiaries and equity-accounted investees amounting to $13,060 as at December 31, 2022 (2021 – $10,241).

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Note 9 Net Earnings Per Share

	2022	2021
Weighted average number of common shares	538,475,000	569,664,000
Dilutive effect of stock options	1,535,000	1,625,000
Weighted average number of diluted common shares	540,010,000	571,289,000

Options excluded from the calculation of diluted net earnings per share due to the option exercise prices being greater than the average market price of common shares were as follows:

	2022	2021
Number of options excluded	567,409	2,393,822
Performance option plan years fully excluded [1]	2012 – 2014	2012 – 2015
Stock option plan years fully excluded	2022	2021

1 Previously granted under a legacy long-term incentive plan.

Note 10 Financial Instruments and Related Risk Management

Our ELT, along with the Board of Directors (including Board of Directors committees), is responsible for monitoring our risk exposures and managing our policies to address these risks. Our strategic and risk management processes are integrated to ensure we understand the benefit from the relationship between strategy, risk and value creation. Outlined below are our risk management strategies we have developed to mitigate the financial market risks that we are exposed to.

Credit Risks	Risk Management Strategies

Receivables from customers	• establish credit approval policies and procedures for new and existing customers
	• extend credit to qualified customers through
	  • review of credit agency reports, financial statements and/or credit references, as available
	  • review of existing customer accounts every 12 to 24 months based on the credit limit amounts
	  • evaluation of customer and country risk for international customers
	• establish credit period:
	  • 15 and 30 days for wholesale fertilizer customers
	  • 30 days for industrial and feed customers
	  • 30 to 360 days for Retail customers, including Nutrien Financial
	  • up to 180 days for select export sales customers, including Canpotex
	• transact on a cash basis with certain customers who may not meet specified benchmark creditworthiness or cannot provide other evidence of ability to pay
	• execute agency arrangements with financial institutions or other partners with which we have only a limited recourse involvement
	• sell receivables to financial institutions which substantially transfer the risks and rewards
	• set eligibility requirements for Nutrien Financial to limit the risk of the receivables
	• may require security over certain crop or livestock inventories
	• set up provision using the lifetime expected credit loss method considering all possible default events over the expected life of a financial instrument. Receivables are grouped based on days past due and/or customer credit risk profile. Estimated losses on receivables are based on known troubled accounts and historical experience of losses incurred. Receivables are considered to be in default and are written off against the allowance when it is probable that all remaining contractual payments due will not be collected in accordance with the terms of the agreement.

Cash and cash equivalents and other receivables	• require acceptable minimum counterparty credit ratings • limit counterparty or credit exposure • select counterparties with investment-grade quality

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Aging of receivables (%) as at December 31:

	2022			2021		
	Retail (Nutrien Financial)	**Retail (Excluding Nutrien Financial)**	**Potash, Nitrogen and Phosphate**	Retail (Nutrien Financial)[1]	Retail (Excluding Nutrien Financial)	Potash, Nitrogen and Phosphate
Current	83	84	97	82	82	96
30 days or less past due	10	9	3	10	12	4
31 – 90 days past due	3	4	–	4	3	–
Greater than 90 days past due	4	3	–	4	3	–
	100	100	100	100	100	100

1 Certain immaterial 2021 figures have been reclassified.

Maximum exposure to credit risk as at December 31:

	2022	2021
Cash and cash equivalents	901	499
Receivables (excluding income tax receivable)	6,050	5,143
	6,951	5,642

Liquidity Risk	**Risk Management Strategies**
Access to cash	• establish an external borrowing policy to maintain sufficient liquid financial resources to fund our operations and meet our commitments and obligations in a cost-effective manner • maintain an optimal capital structure • maintain investment-grade credit ratings that provide ease of access to the debt capital and commercial paper markets • maintain sufficient short-term credit availability • uphold long-term relationships with a sufficient number of high-quality and diverse lenders Refer to Note 17 for our available credit facilities.

The following maturity analysis of our financial liabilities and gross settled derivative contracts (for which the cash flows are settled simultaneously) is based on the expected undiscounted contractual cash flows from the date of the consolidated balance sheets to the contractual maturity date.

2022	**Carrying Amount of Liability as at December 31**	**Contractual Cash Flows**	**Within 1 Year**	**1 to 3 Years**	**3 to 5 Years**	**Over 5 Years**
Short-term debt [1]	2,142	2,142	2,142	–	–	–
Payables and accrued charges [2]	9,683	9,683	9,683	–	–	–
Long-term debt, including current portion [1]	8,582	13,420	932	2,292	1,249	8,947
Lease liabilities, including current portion [1]	1,204	1,374	337	427	199	411
Derivatives	35	35	35	–	–	–
	21,646	26,654	13,129	2,719	1,448	9,358

1 Contractual cash flows include contractual interest payments related to debt obligations and lease liabilities. Interest rates on debt with variable rates are based on the prevailing rates as at December 31, 2022.
2 Excludes non-financial liabilities and includes payables of approximately $1.9 billion related to our prepaid inventory to secure product discounts. We consider these payables to be part of our working capital. For these payables, we participated in arrangements where the vendors sold their right to receive payment to financial institutions without extending the original payment terms. These payables were paid in January 2023.

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Foreign Exchange Risk	Risk Management Strategy
Foreign currency denominated accounts	• execute foreign currency derivative contracts within certain prescribed limits for both forecast operating and capital expenditures to manage the earnings impact, including those related to our equity-accounted investees, that could occur from a reasonably possible strengthening or weakening of the US dollar

The fair value of our net foreign exchange currency derivative (liabilities) assets at December 31, 2022 was $(18) (2021 – $1). The following table presents the significant foreign currency derivatives that existed at December 31:

	2022			2021		
Sell/buy	Notional	Maturities	Average contract rate	Notional	Maturities	Average contract rate
Derivatives not designated as hedges						
Forwards						
USD/Canadian dollars ("CAD")	473	2023	1.3584	522	2022	1.2799
USD/Australian dollars ("AUD")	13	2023	1.5929	19	2022	1.3841
AUD/USD	133	2023	1.5010	113	2022	1.3860
Brazilian real/USD	374	2023	5.6892	135	2022	5.4519
Options						
USD/CAD – buy USD puts	–	–	–	20	2022	1.2500
USD/CAD – sell USD calls	–	–	–	20	2022	1.2600
AUD/USD – buy USD calls	–	–	–	71	2022	1.4060
AUD/USD – sell USD puts	–	–	–	72	2022	1.3797
Derivatives designated as hedges						
Forwards						
USD/CAD	487	2023	1.3255	343	2022	1.2547

Market Risks	Type	Risk Management Strategies	
Interest rate	Short-term and long-term debt	• use a portfolio of fixed and floating rate instruments • align current and long-term assets with demand and fixed-term debt • monitor the effects of market changes in interest rates • use interest rate swaps, if desired	We do not believe we have material exposure to interest or price risk on our financial instruments as at December 31, 2022 and 2021.
Price	Natural gas derivative instruments	• diversify our forecast gas volume requirements, including a portion of annual requirements purchased at spot market prices, a portion at fixed prices (up to 10 years) and a portion indexed to the market price of ammonia • acquire a reliable supply of natural gas feedstock and fuel on a location-adjusted, cost-competitive basis	
Price	Investment at fair value	• ensure the security of principal amounts invested • provide for an adequate degree of liquidity • achieve a satisfactory return	

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Fair Value

Financial instruments included in the consolidated balance sheets are measured either at fair value or amortized cost. The following tables explain the valuation methods used to determine the fair value of each financial instrument and its associated level in the fair value hierarchy.

Financial Instruments at Fair Value	Fair Value Method
Cash and cash equivalents	Carrying amount (approximation to fair value assumed due to short-term nature)
Equity securities	Closing bid price of the common shares as at the balance sheet date
Debt securities	Closing bid price of the debt or other instruments with similar terms and credit risk (Level 2) as at the balance sheet date
Foreign currency derivatives not traded in an active market	Quoted forward exchange rates (Level 2) as at the balance sheet date
Foreign exchange forward contracts, swaps and options, and natural gas swaps not traded in an active market	Based on a discounted cash flow model. Inputs included contractual cash flows based on prices for natural gas futures contracts, fixed prices and notional volumes specified by the swap contracts, the time value of money, liquidity risk, our own credit risk (related to instruments in a liability position) and counterparty credit risk (related to instruments in an asset position). Futures contract prices used as inputs in the model were supported by prices quoted in an active market and therefore categorized in Level 2.

Financial Instruments at Amortized Cost	Fair Value Method
Receivables, short-term debt, and payables and accrued charges	Carrying amount (approximation to fair value assumed due to short-term nature)
Long-term debt	Quoted market prices (Level 1 or 2 depending on the market liquidity of the debt)
Other long-term debt instruments	Carrying amount

The following table presents our fair value hierarchy for financial instruments carried at fair value on a recurring basis or measured at amortized cost and require fair value disclosure:

	2022				2021			
Financial assets (liabilities) measured at	Carrying Amount	Level 1	Level 2	Level 3	Carrying Amount	Level 1	Level 2	Level 3
Fair value on a recurring basis [1]								
Cash and cash equivalents	901	–	901	–	499	–	499	–
Derivative instrument assets	7	–	7	–	19	–	19	–
Other current financial assets – marketable securities [2]	148	19	129	–	134	19	115	–
Investments at fair value through other comprehensive income ("FVTOCI") (Note 15)	200	190	–	10	244	234	–	10
Derivative instrument liabilities	(35)	–	(35)	–	(20)	–	(20)	–
Amortized cost								
Current portion of long-term debt								
Notes and debentures	(500)	(493)	–	–	(500)	(506)	–	–
Fixed and floating rate debt	(42)	–	(42)	–	(45)	–	(45)	–
Long-term debt								
Notes and debentures	(7,910)	(3,581)	(3,656)	–	(7,424)	(4,021)	(4,709)	–
Fixed and floating rate debt	(130)	–	(130)	–	(97)	–	(97)	–

1 During 2022 and 2021, there were no transfers between levels for financial instruments measured at fair value on a recurring basis. Our policy is to recognize transfers at the end of the reporting period.
2 Marketable securities consist of equity and fixed income securities.

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Note 11 Receivables

	Segment	2022	2021
Receivables from customers			
Third parties	Retail (Nutrien Financial) [1]	2,705	2,178
	Retail	1,293	977
	Potash, Nitrogen, Phosphate	827	804
Related party – Canpotex	Potash (Note 28)	866	828
Less allowance for expected credit losses of receivables from customers		(95)	(82)
		5,596	4,705
Rebates		172	222
Income taxes (Note 8)		144	223
Other receivables		282	216
		6,194	5,366

1 Includes $2,260 of very low risk of default and $445 of low risk of default (2021 – $1,792 of very low risk of default and $386 of low risk of default).

Qualifying receivables from customers financed by Nutrien Financial represents high-quality receivables from customers that have been rated very low to low risk of default among Retail's receivables from customers.

Customer credit with a financial institution of $445 at December 31, 2022, related to our agency agreement, is not recognized in our consolidated balance sheets. Through the agency agreement, we only have a limited recourse involvement to the extent of an indemnification of the financial institution to a maximum of 5 percent (2021 – 5 percent) of the qualified customer loans. Historical indemnification losses on this arrangement have been negligible, and the average aging of the customer loans with the financial institution is current.

Note 12 Inventories

	2022	2021
Product purchased for resale	5,885	4,889
Finished products	612	410
Intermediate products	184	206
Raw materials	425	337
Materials and supplies	526	486
	7,632	6,328

By Segment	2022	2021
Retail	6,035	5,018
Potash	398	312
Nitrogen	706	553
Phosphate	493	445
	7,632	6,328

Inventories expensed to cost of goods sold during the year were $21,371 (2021 – $17,243).

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Note 13 Property, Plant and Equipment

	Land and Improvements	Buildings and Improvements	Machinery and Equipment	Mine Development Costs	Assets Under Construction	Total
Useful life range (years)	1 – 85	1 – 70	1 – 80	1 – 60	n/a	
Carrying amount – December 31, 2021	1,073	6,305	10,221	853	1,564	20,016
Acquisitions (Note 25)	12	40	23	–	65	140
Additions	17	9	25	–	2,202	2,253
Additions – Right-of-use ("ROU") assets	–	51	230	–	–	281
Disposals	(9)	(13)	(24)	–	–	(46)
Transfers	35	163	1,281	170	(1,649)	–
Foreign currency translation and other	5	2	55	30	(90)	2
Depreciation	(35)	(185)	(1,006)	(94)	–	(1,320)
Depreciation – ROU assets	(2)	(58)	(279)	–	–	(339)
Reversal of impairment	105	26	491	149	9	780
Carrying amount – December 31, 2022	1,201	6,340	11,017	1,108	2,101	21,767
Balance – December 31, 2022 is composed of:						
Cost	1,605	8,795	22,023	2,699	2,101	37,223
Accumulated depreciation and impairments	(404)	(2,455)	(11,006)	(1,591)	–	(15,456)
Carrying amount – December 31, 2022	1,201	6,340	11,017	1,108	2,101	21,767
Balance – December 31, 2022 is composed of:						
Owned property, plant and equipment	1,173	5,956	10,267	1,108	2,101	20,605
ROU assets	28	384	750	–	–	1,162
Carrying amount – December 31, 2022	1,201	6,340	11,017	1,108	2,101	21,767
Carrying amount – December 31, 2020	1,090	6,305	10,336	723	1,206	19,660
Acquisitions (Note 25)	2	3	5	–	–	10
Additions	7	18	97	–	1,646	1,768
Additions – ROU assets	–	140	238	–	–	378
Disposals	(29)	(21)	(35)	–	(1)	(86)
Transfers	38	142	874	145	(1,199)	–
Foreign currency translation and other	2	(34)	(41)	55	(83)	(101)
Depreciation	(35)	(191)	(991)	(70)	–	(1,287)
Depreciation – ROU assets	(2)	(57)	(248)	–	–	(307)
Impairment	–	–	(14)	–	(5)	(19)
Carrying amount – December 31, 2021	1,073	6,305	10,221	853	1,564	20,016
Balance – December 31, 2021 is composed of:						
Cost	1,547	8,584	20,627	2,496	1,564	34,818
Accumulated depreciation and impairments	(474)	(2,279)	(10,406)	(1,643)	–	(14,802)
Carrying amount – December 31, 2021	1,073	6,305	10,221	853	1,564	20,016
Balance – December 31, 2021 is composed of:						
Owned property, plant and equipment	1,044	5,930	9,517	853	1,564	18,908
ROU assets	29	375	704	–	–	1,108
Carrying amount – December 31, 2021	1,073	6,305	10,221	853	1,564	20,016

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Depreciation of property, plant and equipment was included in the following:

	2022	2021
Freight, transportation and distribution	148	133
Cost of goods sold	1,024	1,052
Selling expenses	424	416
General and administrative expenses	42	36
Depreciation recorded in earnings	1,638	1,637
Depreciation recorded in inventory	151	112

Impairment Reversals

In 2022, we revised our pricing forecasts to reflect the current macroeconomic environment, which triggered an impairment review at our Phosphate cash-generating units ("CGUs"), Aurora and White Springs. In 2020, we recorded a total impairment of assets relating to property plant and equipment at Aurora of $545. In 2017 and 2020, we recorded total impairment of assets at White Springs relating to property, plant and equipment of $250 and $215, respectively.

Due to increases in our forecasts, the recoverable amounts of both CGUs were above their carrying amounts. As a result, we fully reversed the previously recorded impairments, net of depreciation that would have been incurred had no impairment been recognized, in the statement of earnings relating to property, plant and equipment.

Cash-generating units	Aurora	White Springs
Segment	Phosphate	
Impairment reversal indicator	Higher forecasted global prices	
Impairment reversal date	June 30, 2022	September 30, 2022
Valuation methodology	Fair value less costs of disposal ("FVLCD"), a Level 3 measurement	Value in use ("VIU")
Valuation technique	Five-year DCF [1]	DCF [2]
Recoverable amount	2,900	770
Carrying amount	1,200	425
Pre-tax impairment reversal (net of depreciation)	450	330

1 Five-year discounted cash flow plus a terminal year to end of mine life.
2 Discounted cash flow to end of mine life.

The recoverable amount estimate is most sensitive to the following key assumptions: our internal sales and input price forecasts, which consider projections from independent third-party data sources, discount rate and expected mine life. We used key assumptions that were based on historical data and estimates of future results from internal sources, external price benchmarks, and mineral reserve technical reports, as well as industry and market trends.

Cash-generating units	Aurora	White Springs
Key assumptions [1]		
End of mine life (proven and probable reserves) (year)	2050	2030
Long-term growth rate (%)	2.0	n/a
Pre-tax discount rate (%)	n/a	15.2 [2]
Post-tax discount rate (%)	10.4	12.0 [2]
Forecasted EBITDA [3]	3,090	980

1 At impairment reversal date.
2 Discount rate used in the previous measurement was 12.0% (pre-tax – 15.2%).
3 First five years of the forecast period.

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Note 14 Goodwill and Intangible Assets

		Intangible Assets				
	Goodwill	Customer Relationships [2]	Technology	Trade Names	Other	Total
Useful life range (years)	n/a	3 – 15	2 – 20	1 – 20 [3]	1 – 30	
Carrying amount – December 31, 2021	12,220	1,350	595	80	315	2,340
Acquisitions (Note 25)	200	59	–	22	23	104
Additions – internally developed	–	–	216	–	6	222
Foreign currency translation and other	(52)	(13)	14	1	(1)	1
Disposals	–	(1)	(1)	–	–	(2)
Amortization [1]	–	(166)	(122)	(8)	(72)	(368)
Carrying amount – December 31, 2022	12,368	1,229	702	95	271	2,297
Balance – December 31, 2022 is composed of:						
Cost	12,375	2,001	1,028	150	649	3,828
Accumulated amortization and impairment	(7)	(772)	(326)	(55)	(378)	(1,531)
Carrying amount – December 31, 2022	12,368	1,229	702	95	271	2,297
Carrying amount – December 31, 2020	12,198	1,515	437	75	361	2,388
Acquisitions (Note 25)	77	16	–	–	–	16
Additions – internally developed	–	–	118	19	9	146
Foreign currency translation and other	(49)	(15)	143	(3)	13	138
Disposals	(6)	–	–	–	–	–
Cloud computing transition adjustment (Note 6)	–	–	(34)	–	–	(34)
Amortization [1]	–	(166)	(69)	(11)	(68)	(314)
Carrying amount – December 31, 2021	12,220	1,350	595	80	315	2,340
Balance – December 31, 2021 is composed of:						
Cost	12,227	1,961	808	127	619	3,515
Accumulated amortization and impairment	(7)	(611)	(213)	(47)	(304)	(1,175)
Carrying amount – December 31, 2021	12,220	1,350	595	80	315	2,340

1 Amortization of $302 was included in selling expenses during the year ended December 31, 2022 (2021 – $260).
2 The average remaining amortization period of customer relationships as at December 31, 2022, was approximately 4 years.
3 Certain trade names have indefinite useful lives as there are no regulatory, legal, contractual, cooperative, economic or other factors that limit their useful lives.

Goodwill Impairment Testing

Goodwill by cash-generating unit or group of cash-generating units	2022	2021
Retail – North America	6,898	6,898
Retail – International	927	779
Potash	154	154
Nitrogen	4,389	4,389
	12,368	12,220

We performed our annual impairment test on goodwill and did not identify any impairment.

In 2022, North American central banks increased their benchmark borrowing rates, which are a component of our discount rate for impairment testing. As a result of these increases, we revised our discount rates throughout 2022, which triggered impairment testing for our Retail – North America group of CGUs as at June 30, 2022 and September 30, 2022. No impairment was recognized during these interim testing periods.

Goodwill is more susceptible to impairment risk if there is an increase in the discount rate, or a deterioration in business operating results or economic conditions and actual results do not meet our forecasts. As at September 30, 2022, the Retail – North America group of CGUs carrying amount approximated its recoverable amount. A 25 basis point increase in the discount rate would have resulted in an impairment of the carrying amount of goodwill of approximately $500. A decrease in forecasted EBITDA and cash flows or a reduction in the terminal growth rate could result in impairment in the future.

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Retail – North America – Key Assumptions	As at September 30, 2022	As at June 30, 2022
Terminal growth rate (%)	2.5	2.5
Forecasted EBITDA over forecast period (billions)	7.6	7.5
Discount rate (%)	8.5	8.0

In testing for impairment of goodwill, we calculate the recoverable amount for a CGU or groups of CGUs containing goodwill. We used the FVLCD methodology based on after-tax discounted cash flows (five-year projections plus a terminal value) and incorporated assumptions an independent market participant would apply, including considerations related to climate-change initiatives. We adjusted discount rates for each CGU or group of CGUs for the risk associated with achieving our forecasts and for the country risk premium in which we expect to generate cash flows. FVLCD is a Level 3 measurement. We use our market capitalization and comparative market multiples to ensure discounted cash flow results are reasonable.

The key assumptions with the greatest influence on the calculation of the recoverable amounts are the discount rates, terminal growth rates and cash flow forecasts. The key forecast assumptions were based on historical data and our estimates of future results from internal sources considering industry and market trends.

The remaining CGUs were tested as part of our annual impairment test and the following table indicates the key assumptions used:

	Terminal Growth Rate (%)		Discount Rate (%)	
	2022	2021	**2022**	2021
Retail – International [1]	2.0 – 6.0	2.0 – 6.2	8.9 – 16.0	8.0 – 15.5
Potash	2.5	2.5	8.3	7.7
Nitrogen	2.0	2.0	9.3	7.8

1 The discount rates reflect the country risk premium and size for our international groups of CGUs.

Note 15 Investments

Name	Principal Activity	Principal Place of Business and Incorporation	Proportion of Ownership Interest and Voting Rights Held (%)		Carrying Amount	
			2022	2021	**2022**	2021
Equity-accounted investees						
Profertil	Nitrogen producer	Argentina	50	50	453	277
Canpotex	Marketing and logistics of potash	Canada	50	50	–	–
Other associates and joint ventures					190	182
Total equity-accounted investees					643	459
Investments at FVTOCI						
Sinofert	Fertilizer supplier and distributor	China/Bermuda	22	22	190	234
Other					10	10
Total investments at FVTOCI					200	244
Total investments					843	703

We continuously assess our ability to exercise significant influence or joint control over our investments. Our 22 percent ownership in Sinofert does not constitute significant influence as we do not have any representation on the board of directors of Sinofert. We elected to account for our investment in Sinofert as FVTOCI as it is held for strategic purposes.

Future conditions related to Profertil may be affected by political, economic and social instability. We are exposed to foreign exchange risk related to fluctuations in the Argentine peso against the US dollar and currency controls, which may restrict our ability to obtain dividends from Profertil.

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Note 16 Other Assets

	2022	2021
Deferred income tax assets (Note 8)	448	262
Ammonia catalysts – net of accumulated amortization of $94 (2021 – $85)	104	88
Long-term income tax receivable (Note 8)	54	166
Accrued pension benefit assets (Note 21)	157	170
Other	206	143
	969	829

Note 17 Short-term Debt

	Rate of Interest (%)	2022	2021
Credit facilities			
Unsecured revolving term credit facility	5.3	500	-
Other unsecured credit facilities			
South America	1.3 – 76.0	453	74
Australia	3.9	190	211
Other	2.1	9	28
Commercial paper [1]	4.8 – 5.2	783	1,170
Other short-term debt		207	77
		2,142	1,560

1 We use our $4,500 commercial paper program for our short-term cash requirements. The amount available under the commercial paper program is limited to the availability of backup funds under the $4,500 unsecured revolving term credit facility and excess cash invested in highly liquid securities.

Our credit facilities are renegotiated periodically. Our total credit facility limits as at December 31 were:

Credit facilities	2022	2021
Unsecured revolving term facility [1]	4,500	4,500
Unsecured revolving term facility [2]	2,000	-
Uncommitted revolving demand facility	1,000	500
Other credit facilities [3]	1,180	720

1 In 2022, we extended the maturity date from June 4, 2026 to September 14, 2027, subject to extension at the request of Nutrien provided that the resulting maturity date may not exceed five years from the date of request.
2 In 2022, we entered into a new $2,000 unsecured revolving term credit facility, with the same principal covenants and events of default as our existing $4,500 unsecured revolving term credit facility.
3 Total facility limit amounts include some facilities with maturities in excess of one year.

Principal covenants and events of default under the unsecured revolving term credit facilities include a debt to capital ratio (refer to Note 24) and other customary events of default and covenant provisions. Non-compliance with such covenants could result in accelerated repayment and/or termination of the credit facility. We were in compliance with all covenants as at December 31, 2022.

In 2022, to help temporarily manage normal seasonal working capital swings, we entered into non-revolving term credit facilities with an aggregate principal amount of $2,000, which had the same principal covenants and events of default as our existing revolving term credit facilities. The $2,000 non-revolving term credit facilities were fully repaid and subsequently terminated after the new $2,000 unsecured revolving term credit facility was entered into, as described above.

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Note 18 Long-term Debt

	Rate of Interest (%)	Maturity	2022	2021
Notes [1]				
	3.150	October 1, 2022	-	500
	1.900	May 13, 2023	500	500
	5.900	November 7, 2024	500	-
	3.000	April 1, 2025	500	500
	5.950	November 7, 2025	500	-
	4.000	December 15, 2026	500	500
	4.200	April 1, 2029	750	750
	2.950	May 13, 2030	500	500
	4.125	March 15, 2035	450	450
	7.125	May 23, 2036	212	212
	5.875	December 1, 2036	500	500
	5.625	December 1, 2040	500	500
	6.125	January 15, 2041	401	401
	4.900	June 1, 2043	500	500
	5.250	January 15, 2045	489	489
	5.000	April 1, 2049	750	750
	3.950	May 13, 2050	500	500
Debentures [1]	7.800	February 1, 2027	120	120
Other credit facilities [2]	Various	Various	165	141
Other long-term debt	n/a	Various	7	-
			8,344	7,813
Add net unamortized fair value adjustments			310	325
Less net unamortized debt issue costs			(72)	(72)
			8,582	8,066
Less current maturities			(542)	(545)
			8,040	7,521

1 Each series of notes and debentures is unsecured and has no sinking fund requirements prior to maturity. Each series is redeemable and has various provisions that allow redemption prior to maturity, at our option, at specified prices.
2 Other credit facilities are unsecured and consist of South America facilities with debt of $162 (2021 – $137) and interest rates ranging from 1.9 percent to 17.4 percent and other facilities with debt of $3 (2021 – $4) and an interest rate of 4.0 percent.

We are subject to certain customary covenants including limitation on liens, merger and change of control covenants, and customary events of default. As calculated in Note 24, we were in compliance with these covenants as at December 31, 2022.

In millions of US dollars unless otherwise noted

The following is a summary of changes in liabilities arising from financing activities:

	Short-Term Debt	Long-Term Debt	Lease Liabilities	Total
Balance – December 31, 2021	1,560	8,066	1,220	10,846
Cash flows (cash inflows and outflows presented on a net basis)	529	475	(341)	663
Additions and other adjustments to ROU assets	–	–	334	334
Foreign currency translation and other non-cash changes	53	41	(9)	85
Balance – December 31, 2022	2,142	8,582	1,204	11,928
Balance – December 31, 2020	159	10,061	1,140	11,360
Cash flows (cash inflows and outflows presented on a net basis)	1,344	(2,133)	(320)	(1,109)
Loss on early extinguishment of debt	–	142	–	142
Additions and other adjustments to ROU assets	–	–	408	408
Foreign currency translation and other non-cash changes	57	(4)	(8)	45
Balance – December 31, 2021	1,560	8,066	1,220	10,846

Note 19 Lease Liabilities

	Average Rate of Interest (%)	2022	2021
Lease liabilities – non-current	3.3	899	934
Current portion of lease liabilities	3.0	305	286
Total		1,204	1,220

Note 20 Payables and Accrued Charges

	2022	2021
Trade and other payables	5,797	5,179
Customer prepayments	2,298	2,083
Dividends	244	257
Accrued compensation	681	669
Current portion of asset retirement obligations and accrued environmental costs (Note 22)	234	170
Accrued interest	102	80
Current portion of share-based compensation (Note 5)	142	185
Current portion of derivatives	35	20
Income taxes (Note 8)	899	606
Provincial mining taxes	114	53
Other taxes	59	50
Current portion of pension and other post-retirement benefits (Note 21)	15	16
Other accrued charges and others	671	684
	11,291	10,052

Note 21 Pension and Other Post-retirement Benefits

We offer the following pension and other post-retirement benefits to qualified employees: defined benefit pension plans; defined contribution pension plans; and health, dental and life insurance, referred to as other defined benefit plans. Substantially all our employees participate in at least one of these plans.

Description of Defined Benefit Pension Plans

<table>
<tr><th></th><th>Plan Type</th><th>Contributions</th></tr>
<tr><td>United States</td><td rowspan="2">• non-contributory,
• guaranteed annual pension payments for life,
• benefits generally depend on years of service and compensation level in the final years leading up to age 65,
• benefits available starting at age 55 at a reduced rate, and
• plans provide for maximum pensionable salary and maximum annual benefit limits.</td><td>• made to meet or exceed minimum funding requirements of the Employee Retirement Income Security Act of 1974 and associated Internal Revenue Service regulations and procedures.</td></tr>
<tr><td>Canada</td><td>• made to meet or exceed minimum funding requirements based on provincial statutory requirements and associated federal taxation rules.</td></tr>
<tr><td>Supplemental Plans in US and Canada for Senior Management</td><td>• non-contributory,
• unfunded, and
• supplementary pension benefits.</td><td>• provided for by charges to earnings sufficient to meet the projected benefit obligations, and
• payments to plans are made as plan payments to retirees occur.</td></tr>
</table>

Our defined benefit pension plans are funded with separate funds that are legally separated from the Company and administered through an employee benefits or management committee in each country, which is composed of our employees. The employee benefits or management committee is required by law to act in the best interests of the plan participants and, in the US and Canada, is responsible for the governance of the plans, including setting certain policies (e.g., investment and contribution) of the funds. The current investment policy for each country's plans generally does not include any asset/liability matching strategies or currency hedging strategies. Plan assets held in trusts are governed by local regulations and practices in each country, as is the nature of the relationship between the Company and the trustees and their composition.

Description of Other Post-Retirement Plans

We provide health care plans for certain eligible retired employees in the US, Canada and Trinidad. Eligibility for these benefits is generally based on a combination of age and years of service at retirement. Certain terms of the plans include

- coordination with government-provided medical insurance in each country;
- certain unfunded cost-sharing features such as co-insurance, deductibles and co-payments – benefits subject to change;
- for certain plans, maximum lifetime benefits;
- at retirement, the employee's spouse and certain dependent children may be eligible for coverage;
- benefits are self-insured and are administered through third-party providers; and
- generally, retirees contribute towards annual cost of the plans.

We provide non-contributory life insurance plans for certain retired employees who meet specific age and service eligibility requirements.

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Risks

The defined benefit pension and other post-retirement plans expose us to broadly similar actuarial risks. The most significant risks include investment risk and interest rate risk as discussed below. Other risks include longevity risk and salary risk.

Investment risk	A deficit will be created if plan assets underperform the discount rate used in the defined benefit obligation valuation. To mitigate investment risk, we employ • a total return on investment approach whereby a diversified mix of equities and fixed income investments is used to maximize long-term return for a prudent level of risk; and • risk tolerance established through careful consideration of plan liabilities, plan funded status and corporate financial condition. Other assets such as private equity and hedge funds are not used at this time. Our policy is not to invest in commodities, precious metals, mineral rights, bullions or collectibles. Investment risk is measured and monitored on an ongoing basis through quarterly investment portfolio reviews, annual liability measurements and periodic asset/liability studies.
Interest rate risk	A decrease in bond interest rates will increase the pension liability; however, this is generally expected to be partially offset by an increase in the return on the plan's debt investments.

Financial Information

	2022			2021		
	Obligation	**Plan Assets**	**Net**	Obligation	Plan Assets	Net
Balance – beginning of year	(1,996)	1,731	(265)	(2,066)	1,706	(360)
Components of defined benefit expense recognized in earnings						
Current service cost for benefits earned during the year	(27)	–	(27)	(36)	–	(36)
Interest (expense) income	(60)	52	(8)	(57)	48	(9)
Past service cost, including curtailment gains and settlements	24	(39)	(15)	(2)	–	(2)
Foreign exchange rate changes and other	28	(21)	7	(7)	(1)	(8)
Subtotal of components of defined benefit (recovery) expense recognized in earnings	(35)	(8)	(43)	(102)	47	(55)
Remeasurements of the net defined benefit liability recognized in OCI during the year						
Actuarial gain arising from:						
Changes in financial assumptions	423	–	423	83	–	83
Changes in demographic assumptions	21	–	21	9	–	9
(Loss) gain on plan assets (excluding amounts included in net interest)	–	(337)	(337)	–	33	33
Subtotal of remeasurements [2]	444	(337)	107	92	33	125
Cash flows						
Contributions by plan participants	(6)	6	–	(6)	6	–
Employer contributions	–	24	24	–	25	25
Benefits paid	86	(86)	–	86	(86)	–
Subtotal of cash flows	80	(56)	24	80	(55)	25
Balance – end of year [1]	(1,507)	1,330	(177)	(1,996)	1,731	(265)
Balance is composed of:						
Non-current assets						
Other assets (Note 16)			157			170
Current liabilities						
Payables and accrued charges (Note 20)			(15)			(16)
Non-current liabilities						
Pension and other post-retirement benefit liabilities			(319)			(419)

1 Obligations arising from funded and unfunded pension plans are $1,255 and $252 (2021 – $1,659 and $337), respectively. Other post-retirement benefit plans have no plan assets and are unfunded.
2 Certain immaterial figures have been reclassified in 2021.

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Plan Assets

As at December 31, the fair value of plan assets of our defined benefit pension plans, by asset category, were as follows:

	2022			2021		
	Quoted Prices in Active Markets for Identical Assets	**Other [1]**	**Total**	Quoted Prices in Active Markets for Identical Assets	Other [1]	Total
Cash and cash equivalents	93	4	97	11	7	18
Equity securities and equity funds						
US	8	107	115	22	257	279
International	–	14	14	–	28	28
Debt securities [2]	–	841	841	–	1,020	1,020
Other	–	263	263	–	386	386
Total pension plan assets	101	1,229	1,330	33	1,698	1,731

1 Approximately 100 percent (2021 – 100 percent) of the Other plan assets are held in funds whose fair values are estimated using their net asset value per share. For the majority of these funds, the redemption frequency is immediate. The Plan Committee manages the asset allocation based upon our current liquidity and income needs.
2 Debt securities included US securities of 77 percent (2021 – 71 percent) and International securities of 22 percent (2021 – 28 percent) and Mortgage Backed Securities of 1 percent (2021 – 1 percent).

We use letters of credit or surety bonds to secure certain Canadian unfunded defined benefit plan liabilities as at December 31, 2022.

We expect to contribute approximately $128 to all pension and post-retirement plans in 2023. Total contributions recognized as expense under all defined contribution plans for 2022 was $128 (2021 – $111).

We used the following significant assumptions to determine the benefit obligations and expense for our significant plans as at and for the year ended December 31. These assumptions are determined by management and are reviewed annually by our independent actuaries.

	Pension		Other	
	2022	2021	**2022**	2021
Assumptions used to determine the benefit obligations [1]:				
Discount rate (%)	5.01	3.09	4.86	2.97
Rate of increase in compensation levels (%)	4.29	4.27	n/a	n/a
Medical cost trend rate – assumed (%) [2]	n/a	n/a	4.50 – 7.00	4.50 – 6.50
Medical cost trend rate – year reaches ultimate trend rate	n/a	n/a	2033	2030
Mortality assumptions (years) [3]				
Life expectancy at 65 for a male member currently at age 65	20.6	20.7	20.5	20.6
Life expectancy at 65 for a female member currently at age 65	22.9	22.9	23.2	23.2
Average duration of the defined benefit obligations (years) [4]	12.7	15.3	12.8	14.9

1 The current year's expense is determined using the assumptions that existed at the end of the previous year.
2 We assumed a graded medical cost trend rate starting at 7.00 percent in 2022, moving to 4.50 percent by 2033 (2021 – starting at 6.50 percent, moving to 4.50 percent by 2030).
3 Based on actuarial advice in accordance with the latest available published tables, adjusted where appropriate to reflect future longevity improvements for each country.
4 Weighted average length of the underlying cash flows.

Of the most significant assumptions, a change in discount rates has the greatest potential impact on our pension and other post-retirement benefit plans, with sensitivity to change as follows:

		2022		2021	
	Change in Assumption	**Benefit Obligations**	**Expense in Earnings Before Income Taxes**	Benefit Obligations	Expense in Earnings Before Income Taxes
As reported		1,507	43	1,996	55
Discount rate	1.0 percentage point decrease	210	20	330	20
	1.0 percentage point increase	(170)	(20)	(260)	(20)

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Note 22 Asset Retirement Obligations and Accrued Environmental Costs

December 31, 2022	Cash Flow Payments (years) [1]	Discounted Cash Flows [2,3]	Discount Rate +0.5%	Discount Rate -0.5%
Asset retirement obligations			(60)	80
Retail	1 – 30	21		
Potash	29 – 462	102		
Phosphate	1 – 78	518		
Corporate and others [4,5]	1 – 484	546		
Accrued environmental costs			(5)	5
Retail	1 – 30	75		
Corporate and others	1 – 20	375		
Total		1,637		

1 Time frame in which payments are expected to principally occur from December 31, 2022. Adjustments to the years can result from changes to the mine life and/or changes in the rate of tailings volumes.
2 Risk-free discount rates used to discount cash flows reflect current market assessments of the time value of money and the risks specific to the timing and jurisdiction of the obligation. Risk-free rates range from 3.0 percent to 5.5 percent.
3 Total undiscounted cash flows are $4.0 billion. For the Potash segment, this represents total undiscounted cash flows in the first year of decommissioning. This excludes subsequent years of tailings dissolution, fine tails capping, tailings management area reclamation, post-reclamation activities and monitoring, and final decommissioning, which are estimated to take an additional 125 to 433 years.
4 For nitrogen sites, we have not recorded any asset retirement obligations as no significant asset retirement obligations have been identified or there is no reasonable basis for estimating a date or range of dates of cessation of operations. We considered the historical performance of our facilities as well as our planned maintenance, major upgrades and replacements, which can extend the useful lives of our facilities indefinitely.
5 Includes certain potash and phosphate sites that are non-operating sites, with the majority of phosphate site payments taking place over the next 17 years.

	Asset Retirement Obligations	Accrued Environmental Costs	Total
Balance – December 31, 2021	1,231	505	1,736
Disposals	–	(7)	(7)
Change in estimates	36	2	38
Settlements	(81)	(41)	(122)
Accretion	27	2	29
Foreign currency translation and other	(26)	(11)	(37)
Balance – December 31, 2022	1,187	450	1,637
Balance – December 31, 2022 is composed of:			
Current liabilities			
Payables and accrued charges (Note 20)	165	69	234
Non-current liabilities			
Asset retirement obligations and accrued environmental costs	1,022	381	1,403

We are subject to numerous environmental requirements under federal, provincial, state and local laws in the countries in which we operate. We have gypsum stack capping, and closure and post-closure obligations through our subsidiaries, PCS Phosphate Company, Inc. in White Springs, Florida, and PCS Nitrogen Inc. in Geismar, Louisiana, pursuant to the financial assurance regulatory requirements in those states. As at December 31, 2022, we had $391 in surety bonds and letters of credit outstanding relating to these financial assurance obligations. The recorded provisions may not necessarily reflect our obligations under these financial assurances.

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Note 23 Share Capital

Authorized

We are authorized to issue an unlimited number of common shares without par value and an unlimited number of preferred shares. The common shares are not redeemable or convertible. The preferred shares may be issued in one or more series with rights and conditions to be determined by the Board of Directors.

Issued

	Number of Common Shares	Share Capital
Balance – December 31, 2021	557,492,516	15,457
Issued under option plans and share-settled plans	3,066,148	202
Repurchased	(53,312,559)	(1,487)
Balance – December 31, 2022	**507,246,105**	**14,172**

Share Repurchase Programs

	Commencement Date	Expiry	Maximum Shares for Repurchase	Maximum Shares for Repurchase (%)	Number of Shares Repurchased
2020 Normal Course Issuer Bid	February 27, 2020	February 26, 2021	28,572,458	5	710,100
2021 Normal Course Issuer Bid	March 1, 2021	February 28, 2022	28,468,448	5	22,186,395
2022 Normal Course Issuer Bid [1]	March 1, 2022	February 7, 2023	55,111,110	10	47,108,318
2023 Normal Course Issuer Bid [2]	**March 1, 2023**	**February 29, 2024**	**24,962,194**	**5**	**–**

1 The original expiry date was February 28, 2023, but we acquired the maximum aggregate number of common shares allowable on February 7, 2023. As of February 7, 2023, an additional 8,002,792 common shares were repurchased for cancellation at a cost of $625 and an average price per share of $78.07.
2 On February 15, 2023, our Board of Directors approved a share repurchase program. The 2023 normal course issuer, which is subject to acceptance by the Toronto Stock Exchange, will expire earlier than the date above if we acquire the maximum number of common shares allowable or otherwise decide not to make any further repurchases.

Purchases under the normal course issuer bids were, or may be, made through open market purchases at market prices as well as by other means permitted by applicable securities regulatory authorities, including private agreements.

Summary of share repurchases	2022	2021
Number of common shares repurchased for cancellation	53,312,559	15,982,154
Average price per share (US dollars)	84.34	69.17
Total cost	4,496	1,105

Dividends Declared

	2022		2021
Declared	**Per Share**	Declared	Per Share
February 16, 2022	0.48	February 17, 2021	0.46
May 18, 2022	0.48	May 17, 2021	0.46
August 4, 2022	0.48	August 9, 2021	0.46
November 3, 2022	0.48	November 1, 2021	0.46
	1.92		1.84

On February 15, 2023, our Board of Directors declared a quarterly dividend to $0.53 per share payable on April 13, 2023, to shareholders of record on March 31, 2023. The total estimated dividend to be paid is $265.

In millions of US dollars unless otherwise noted

Note 24 Capital Management

Our capital allocation policy prioritizes safe and reliable operations, a healthy balance sheet, a sustainable dividend to shareholders, and a strategy to allocate remaining cash flow that maximizes shareholder value.

We include total debt, adjusted total debt, adjusted net debt and adjusted shareholders' equity as components of our capital structure. We monitor our capital structure and, based on changes in economic conditions, may adjust the structure by adjusting the amount of dividends paid to shareholders, repurchasing shares, issuing new shares, issuing new debt or retiring existing debt.

We have access to the capital markets through our base shelf prospectus. We use a combination of short-term and long-term debt to finance our operations. We typically pay floating rates of interest on short-term debt and credit facilities, and fixed rates on notes and debentures.

We monitor the following measures to evaluate our ability to service debt, make strategic investments and ensure we are in compliance with our debt covenants:

	2022	2021
Adjusted net debt to adjusted EBITDA	0.9	1.4
Adjusted EBITDA to adjusted finance costs	21.6	14.3
Debt to capital (calculated as adjusted total debt to adjusted capital) (Limit: 0.65 : 1.00)	0.32 : 1.00	0.32 : 1.00

Adjusted EBITDA is calculated in Note 3, while the calculation of the remaining components included in the above ratios are set out in the following tables:

	2022	2021
Short-term debt	2,142	1,560
Current portion of long-term debt	542	545
Current portion of lease liabilities	305	286
Long-term debt	8,040	7,521
Lease liabilities	899	934
Total debt	11,928	10,846
Letters of credit – financial	97	114
Adjusted total debt	12,025	10,960

	2022	2021
Total debt	11,928	10,846
Cash and cash equivalents	(901)	(499)
Unamortized fair value adjustments	(310)	(325)
Adjusted net debt	10,717	10,022

	2022	2021
Total shareholders' equity	25,863	23,699
Adjusted total debt	12,025	10,960
Adjusted capital	37,888	34,659

	2022	2021
Finance costs	563	613
Unwinding of discount on asset retirement obligations	(29)	9
Borrowing costs capitalized to property, plant and equipment	37	29
Interest on net defined benefit pension and other post-retirement plan obligations	(8)	(9)
Loss on early extinguishment of debt	-	(142)
Adjusted finance costs	563	500

In 2022, we filed a base shelf prospectus in Canada and the US qualifying the issuance of up to $5 billion of common shares, debt securities and other securities during a period of 25 months from March 11, 2022. In 2022, we issued $1 billion of notes pursuant to the base shelf prospectus and a prospectus supplement, as discussed in Note 18.

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Note 25 Business Combinations

	Casa do Adubo S.A. ("Casa do Adubo")	Other Acquisitions
Acquisition date	October 1, 2022	Various
Purchase price, net of cash and cash equivalents acquired, and amounts held in escrow	$231 (preliminary) On the acquisition date, we acquired 100% of the issued and outstanding Casa do Adubo stock.	$176 (preliminary) (2021 – $88)
Goodwill and expected benefits of acquisitions	$145 (preliminary)	$55 (preliminary) (2021 – $77)
	The expected benefits of the acquisitions resulting in goodwill include • synergies from expected reduction in operating costs • wider distribution channel for selling products of acquired businesses • a larger assembled workforce • potential increase in customer base • enhanced ability to innovate	
Description	An agriculture retailer in Brazil with 39 retail locations and 10 distribution centers. This acquisition is aligned with our disciplined approach to capital allocation and sustainability commitments, as we continue to expand our presence in Brazil.	2022 – 43 Retail locations related to various agricultural services and one wholesale warehouse location (2021 – 36 Retail locations)

We have engaged independent valuation experts to assist in determining the fair value of certain assets acquired and liabilities assumed and related deferred income tax impacts. As at December 31, 2022, the total consideration and purchase price allocation for Casa do Adubo and certain other acquisitions are not final as we are continuing to obtain and verify information required to determine the fair value of certain assets acquired and liabilities assumed and the amount of deferred income taxes arising on their recognition, as part of the due diligence process. We expect to finalize the amounts recognized as we obtain the information necessary to complete the analysis within one year from the date of acquisition.

We allocated the following values to the acquired assets and assumed liabilities based upon fair values at their respective acquisition date. The information below represents preliminary fair values. For certain other acquisitions, we finalized the purchase price with no material change to the fair values disclosed in prior periods. Refer to Note 30 for details of our valuation technique and judgments applied.

In millions of US dollars unless otherwise noted

	2022 Casa do Adubo (Preliminary)	2022 Other Acquisitions (Preliminary)	2021 Other Acquisitions
Receivables	174 [1]	11	43
Inventories	107	92	24
Prepaid expenses and other current assets	3	13	–
Property, plant and equipment	24	116	10
Goodwill	145 [2]	55	77
Intangible assets	95	9	16
Investments	–	2	–
Other non-current assets	6	4	4
Total assets	554	302	174
Short-term debt	14 [3]	11	11
Payables and accrued charges	159	74	50
Long-term debt, including current portion	91	14	7
Lease liabilities, including current portion	10	3	1
Other non-current liabilities	1	14	17
Total liabilities	275	116	86
Total consideration	279	186	88
Amounts held in escrow	(48)	(10)	–
Total consideration, net of cash and cash equivalents acquired, and amounts held in escrow	231	176	88

1 Includes receivables from customers with gross contractual amounts of $169, of which $3 is considered to be uncollectible.
2 Goodwill was calculated as the excess of the fair value of consideration transferred over the recognized amount of net identifiable assets acquired. The portion of goodwill deductible for income tax purposes will be determined when the purchase allocation is finalized.
3 Outstanding amount on the Casa do Adubo credit facilities assumed as part of the acquisition.

Financial Information Related to the Acquired Operations

2022 Proforma (estimated as if acquisitions occurred at the beginning of the year)	Casa do Adubo	Other Acquisitions
Sales	440	240
Earnings before finance costs and income taxes[1]	42	13

1 Net earnings is not available.

From date of acquisition	2022 Actuals Casa do Adubo	2022 Actuals Other Acquisitions	2021 Actuals Other Acquisitions
Sales	130	100	80
Earnings before finance costs and income taxes	7	7	7

Note 26 Commitments

December 31, 2022	Principal Portion and Estimated Interest: Lease Liabilities	Principal Portion and Estimated Interest: Long-Term Debt	Purchase Commitments	Capital Commitments	Other Commitments	Total
Within 1 year	337	932	1,533	178	169	3,149
1 to 3 years	427	2,292	72	40	143	2,974
3 to 5 years	199	1,249	24	–	74	1,546
Over 5 years	411	8,947	120	–	58	9,536
Total	1,374	13,420	1,749	218	444	17,205

Purchase Commitments

We have a long-term natural gas purchase agreement in Trinidad that expires on December 31, 2023. The contract provides for prices that vary primarily with ammonia market prices and annual escalating floor prices. The commitments included in the foregoing table are based on floor prices and minimum purchase quantities.

Profertil has various gas contracts denominated in US dollars that expire in 2023 and 2025 and account for virtually all of Profertil's gas requirements. YPF S.A., our joint venture partner in Profertil, supplies approximately 70 percent of the gas under these contracts.

The Carseland facility has a power cogeneration agreement, expiring on December 31, 2026, which provides 60 megawatt-hours of power per hour. The price for the power is based on a fixed charge adjusted for inflation and a variable charge based on the cost of natural gas provided to the facility for power generation.

Agreements for the purchase of sulfur for use in production of phosphoric acid provide for specified purchase quantities and prices based on market rates at the time of delivery. Commitments included in the foregoing table are based on expected contract prices.

As part of the agreement to sell the Conda Phosphate operations ("Conda"), we entered into long-term strategic supply and offtake agreements that end in 2023. Under the terms of the supply and offtake agreements, we will supply 100 percent of the ammonia requirements of Conda and purchase 100 percent of the monoammonium phosphate ("MAP") product produced at Conda. The MAP production is estimated at 330,000 tonnes per year.

Other Commitments

Other commitments consist principally of pipeline capacity, technology service contracts, managed services contracts, throughput and various rail contracts, the latest of which expires in 2036, and mineral lease commitments, the latest of which expires in 2033.

Note 27 Guarantees

In the normal course of business, we provide indemnification agreements to counterparties in transactions such as purchase and sale contracts, service agreements, director/officer contracts, and leasing transactions. The terms of these indemnification agreements

- may require us to compensate counterparties for costs incurred as a result of various events, including environmental liabilities and changes in (or in the interpretation of) laws and regulations, or as a result of litigation claims or statutory sanctions that may be suffered by a counterparty as a consequence of the transaction;
- will vary based upon the contract, the nature of which prevents us from making a reasonable estimate of the maximum potential amount that we could be required to pay to counterparties; and
- have not historically resulted in any significant payments by Nutrien and, as at December 31, 2022, no amounts have been accrued in the consolidated financial statements (except for accruals relating to certain underlying liabilities).

We directly guarantee our share of certain commitments of Canpotex (such as railcar leases) under certain agreements with third parties. We would be required to perform on these guarantees in the event of default by the investee. No material loss is anticipated by reason of such agreements and guarantees.

Note 28 Related Party Transactions

Sale of Goods

We sell potash outside Canada and the US exclusively through Canpotex. Canpotex sells potash to buyers in export markets pursuant to term and spot contracts at agreed upon prices. Our total revenue is recognized at the amount received from Canpotex representing proceeds from their sale of potash, less net costs of Canpotex. Sales to Canpotex are shown in Note 3. The receivable outstanding from Canpotex is shown in Note 11 and arose from sale transactions described above. It is unsecured and bears no interest. There are no expected credit losses held against this receivable.

In millions of US dollars unless otherwise noted

Key Management Personnel Compensation and Transactions with Post-Employment Benefit Plans

	2022	2021
Salaries and other short-term benefits	13	16
Share-based compensation	18	55
Post-employment benefits	3	4
Termination benefits	10	7
	44	82

Disclosures related to our post-employment benefit plans are shown in Note 21.

Note 29 Contingencies and Other Matters

Accounting Estimates and Judgments

The following judgments are required to determine our exposure to possible losses and gains related to environmental matters and other various claims and lawsuits pending:

- prediction of the outcome of uncertain events (i.e., being virtually certain, probable, remote or undeterminable);
- determination of whether recognition or disclosure in the consolidated financial statements is required; and
- estimation of potential financial effects.

Where no amounts are recognized, such amounts are contingent and disclosure may be appropriate. While the amount disclosed in the consolidated financial statements may not be material, the potential for large liabilities exists and, therefore, these estimates could have a material impact on our consolidated financial statements.

Supporting Information

Canpotex

Nutrien is a shareholder in Canpotex, which markets Canadian potash outside of Canada and the US. Should any operating losses or other liabilities be incurred by Canpotex, the shareholders have contractually agreed to reimburse it in proportion to each shareholder's productive capacity. Through December 31, 2022, we are not aware of any operating losses or other liabilities.

Mining Risk

The risk of underground water inflows and other underground risks is insured on a limited basis, subject to insurance market availability. Through December 31, 2022, we are not aware of any material losses or other liabilities that we have not accrued for.

Environmental Remediation, Legal and Other Matters

We are engaged in ongoing site assessment and/or remediation activities at a number of facilities and sites. Anticipated costs associated with these matters are added to accrued environmental costs in the manner described in Note 22.

We have established provisions for environmental site assessment and/or remediation matters to the extent that we consider expenses associated with those matters likely to be incurred. Except for the uncertainties described below, we do not believe that our future obligations with respect to these matters are reasonably likely to have a material adverse effect on our consolidated financial statements.

Legal matters with significant uncertainties include the following:

- The United States Environmental Protection Agency ("US EPA") has an ongoing enforcement initiative directed at the phosphate industry related to the scope of an exemption for mineral processing wastes under the US Resource Conservation and Recovery Act ("RCRA"). This initiative affects the Conda Phosphate plant previously owned by Nu-West Industries, Inc. ("Nu-West"), a wholly owned subsidiary of Nutrien (Canada) Holdings ULC, and the Nutrien phosphoric acid facilities in Aurora, North Carolina; Geismar, Louisiana; and White Springs, Florida. Nutrien facilities received US EPA notices of violation ("NOVs") for alleged violations of the RCRA and various other environmental laws. Notwithstanding the sale of the Conda Phosphate operations in January 2018, Nu-West remains responsible for environmental liabilities attributable to its historic activities and for resolution of the NOVs. The facilities have been and continue to be involved in ongoing discussions with the US EPA, the US Department of Justice and the related state agencies to resolve these matters, with one such settlement being reached in 2022 for the Geismar, Louisiana facility. The Geismar consent decree was entered on October 19, 2022, and resolved the allegations associated with the historic phosphoric acid operations at that facility. Due to the nature of the allegations at the other facilities, we are uncertain as to how the matters will be resolved. Based on settlements with other members of the phosphate industry and the Geismar consent decree, we expect that a resolution could involve any or all of the following: 1) penalties, which we currently believe will not be material; 2) modification of certain operating practices; 3) capital improvement projects; 4) providing financial assurance for the future closure, maintenance and monitoring costs for the phosphogypsum stack system; and 5) addressing findings resulting from the RCRA section 3013 site investigations.
- We operate in countries that are parties to the Paris Agreement adopted in December 2015 pursuant to the United Nations Framework Convention on Climate Change. Each country that is a party to the Paris Agreement submitted an Intended Nationally Determined Contribution ("INDC") towards the control of greenhouse gas emissions. The impacts on our operations of these INDCs and other national and local efforts to limit or tax greenhouse gas emissions cannot be determined with any certainty at this time.

In addition, various other claims and lawsuits are pending against the Company in the ordinary course of business. While it is not possible to determine the ultimate outcome of such actions at this time, and inherent uncertainties exist in predicting such outcomes, we believe that the ultimate resolution of such actions is not reasonably likely to have a material adverse effect on our consolidated financial statements.

The breadth of our operations and the global complexity of tax regulations require assessments of uncertainties and judgments in estimating the taxes we will ultimately pay. The final taxes paid are dependent upon many factors, including negotiations with taxing authorities in various jurisdictions, outcomes of tax litigation, and resolution of disputes arising from federal, provincial, state and local tax audits. The resolution of these uncertainties and the associated final taxes may result in adjustments to our tax assets and tax liabilities.

We own facilities that have been either permanently or indefinitely shut down. We expect to incur nominal annual expenditures for site security and other maintenance costs at some of these facilities. Should the facilities be dismantled, certain other shutdown-related costs may be incurred. Such costs are not expected to have a material adverse effect on our consolidated financial statements and would be recognized and recorded in the period in which they are incurred.

Note 30 Accounting Policies, Estimates and Judgments

The following discusses the significant accounting policies, estimates, judgments and assumptions that we have adopted and applied and how they affect the amounts reported in the consolidated financial statements. Certain of our policies involve accounting estimates and judgments because they require us to make subjective or complex judgments about matters that are inherently uncertain and because of the likelihood that materially different amounts could be reported under different conditions or using different assumptions.

Basis of Consolidation

These consolidated financial statements include the accounts of the Company and entities we control.

- Subsidiaries are fully consolidated from the date on which control is transferred to the Company until the date on which control ceases. They are deconsolidated from the date that control ceases.
- Intercompany balances and transactions are eliminated on consolidation.

<table>
<tr><th>Principal (wholly owned) Operating Subsidiaries</th><th>Location</th><th>Principal Activity</th></tr>
<tr><td>Potash Corporation of Saskatchewan Inc.</td><td>Canada</td><td>Mining and/or processing of crop nutrients and corporate functions</td></tr>
<tr><td>Nutrien (Canada) Holdings ULC</td><td>Canada</td><td>Manufacturer and distributor of crop nutrients and corporate functions</td></tr>
<tr><td>Agrium Canada Partnership</td><td>Canada</td><td rowspan="5">Manufacturer and distributor of crop nutrients</td></tr>
<tr><td>Agrium Potash Ltd.</td><td>Canada</td></tr>
<tr><td>Nutrien US LLC</td><td>US</td></tr>
<tr><td>Cominco Fertilizer Partnership</td><td>US</td></tr>
<tr><td>Loveland Products Inc.</td><td>US</td></tr>
<tr><td>Nutrien Ag Solutions Argentina S.A</td><td>Argentina</td><td rowspan="4">Crop input retailer</td></tr>
<tr><td>Nutrien Ag Solutions (Canada) Inc.</td><td>Canada</td></tr>
<tr><td>Nutrien Ag Solutions, Inc.</td><td>US</td></tr>
<tr><td>Nutrien Ag Solutions Limited</td><td>Australia</td></tr>
<tr><td>PCS Nitrogen Fertilizer, LP</td><td>US</td><td>Production of nitrogen products in the US</td></tr>
<tr><td>PCS Nitrogen Ohio LP</td><td>US</td><td>Production of nitrogen products in the state of Ohio</td></tr>
<tr><td>PCS Nitrogen Trinidad Limited</td><td>Trinidad</td><td>Production of nitrogen products in Trinidad</td></tr>
<tr><td>PCS Phosphate Company, Inc.</td><td>US</td><td>Mining and/or processing of phosphate products</td></tr>
<tr><td>PCS Sales (USA) Inc.</td><td>US</td><td>Marketing and sales of the Company's products</td></tr>
<tr><td>Phosphate Holding Company, Inc.</td><td>US</td><td>Mining and/or processing of phosphate products and production of nitrogen products in the US</td></tr>
</table>

Climate Change

In 2021, we announced our Environmental, Social and Governance ("ESG") commitment to help address our key climate-related risks related to climate change and reduce our carbon footprint described in our Feeding the Future Plan. During 2022 there has been continued progress by Nutrien to deliver on our action plan and sustained development of the ESG frameworks and regulatory initiatives. We recognize that these developments could further impact our accounting estimates and judgments including, but not limited to, assessment of our asset useful lives, impairment of other long-lived assets, and asset retirement obligations and accrued environmental costs. We have monitored and will continue to monitor these developments as they affect our consolidated financial statements.

Foreign Currency Transactions

The consolidated financial statements are presented in US dollars, which we determined to be the functional currency of the Company and the majority of our subsidiaries. In determining the functional currency of our operations, we primarily considered the currency that determines the pricing of transactions rather than focusing on the currency in which transactions are denominated.

Foreign exchange gains and losses resulting from the settlement of foreign currency transactions, and from the translation at period-end of monetary assets and liabilities denominated in foreign currencies, are recognized and presented in the consolidated statements of earnings within other (income) expenses, as applicable, in the period in which they arise. Non-monetary assets measured at historical cost are translated at the average monthly exchange rate prevailing at the time of the transaction, unless the exchange rate in effect on the date of the transaction is available and it is apparent that such rate is a more suitable measurement.

Assets and liabilities in foreign operations are translated using the period-end rate, while the income and expenses are translated using the average monthly exchange rate. Equity of the foreign operation is translated using the historical rate at the time of the acquisition. Exchange gains and losses resulting from translation are recognized in other comprehensive income and accumulated in a separate reserve within equity. The cumulative amount is reclassified to profit or loss when the foreign operation is disposed of.

Revenue

We recognize revenue when we transfer control over a good or service to a customer.

Transfer of Control for Sale of Goods	Transfer of Control for Sale of Services
At the point in time when the product is • purchased at our Retail farm center, • delivered and accepted by customers at their premises, or • loaded for shipping.	Over time as the promised service is rendered.

Judgment is used to determine whether we are acting as principal or agent by evaluating who

- has the primary responsibility for fulfilling the promised good;
- bears the inventory risk including if the vendor has the right to have its product returned on demand; and
- has discretion for establishing the price.

For transactions in which we act as an agent rather than the principal, revenue is recognized net of any commissions earned. The related commissions are recognized as the sales occur or as unconditional contracts are signed.

We recognize profits on sales to Canpotex when there is a transfer of control, either at the time the product is loaded for shipping or delivered, depending on the terms of the contract. Sales are recognized using a provisional price at the time control is transferred to Canpotex, with the final pricing determined upon Canpotex's final sale to a third party (generally between one and three months from date of sale to Canpotex).

Our sales revenue relating to our Potash, Nitrogen and Phosphate segments is generally recorded and measured based on the "freight on board" mine, plant, warehouse or terminal price specified in the contract (except for certain vessel sales or specific product sales that are shipped and recorded on a delivered basis), which reflects the consideration we expect to be entitled to in exchange for the goods or services, net of any variable consideration (e.g., any trade discounts or estimated volume rebates). Our customer contracts may provide certain product quality specification guarantees but do not generally provide for refunds or returns. Sales prices are based on North American and international benchmark market prices, which are subject to global supply and demand, and other market factors.

For our Retail segment, we do not provide general warranties; however, our customer contracts may provide certain product quality specification guarantees. Returns and incentives are estimated based on historical and forecasted data, contractual terms, and current conditions.

Transportation costs are generally recovered from the customer through sales pricing. Where customer contracts include volume rebates, we estimate revenue at the earlier of when the most likely amount of consideration we expect to receive has been determined or when it is highly probable that a significant reversal will not occur.

Due to the nature of goods and services sold, any single estimate would have only a negligible impact on revenue.

As the expected period between when control over a promised good or service is transferred and when the customer pays for that good or service is generally less than 12 months, we apply the practical expedient as provided in IFRS 15, "Revenue from Contracts with Customers," and do not adjust the promised amount of consideration for the effects of financing.

Intersegment sales are made under terms that approximate market value.

Seasonality in our business results from increased demand for products during planting season. Crop input sales are generally higher in the spring and fall application seasons. Crop nutrient inventories are normally accumulated leading up to each application season. Our cash collections generally occur after the application season is complete, while customer prepayments made to us are typically concentrated in December and January and inventory prepayments paid to our suppliers are typically concentrated in the period from November to January. Feed and industrial sales are more evenly distributed throughout the year.

Share-Based Compensation

For awards with performance conditions that determine the number of options or units to which employees are entitled, measurement of compensation cost is based on our best estimate of the outcome of the performance conditions. Changes to vesting assumptions are reflected in earnings immediately for compensation cost already recognized.

For Plans Settled Through the Issuance of Equity	For Plans Settled Through Cash
• fair value for stock options is determined on grant date using the Black-Scholes-Merton option-pricing model, and	• a liability is recorded based on the fair value of the awards each period.

Estimation involves determining:

- stock option-pricing model assumptions as described in the weighted average assumptions table in Note 5;
- forfeiture rate for options granted based on past experience and future expectations, and adjusted upon actual vesting; and
- projected outcome of performance conditions for PSUs, including our return on invested capital compared to Nutrien's weighted average cost of capital, and including the relative ranking of our total shareholder return, including expected dividends, compared with a specified peer group using a Monte Carlo simulation option-pricing model; and
- the number of dividend equivalent units expected to be earned.

Income Taxes

Taxation on earnings (loss) is composed of current and deferred income tax. Taxation is recognized in the statements of earnings unless it relates to items recognized either in OCI or directly in shareholders' equity.

Current Income Tax	Deferred Income Tax
• is the expected tax payable on the taxable earnings for the year and includes any adjustments to income tax payable or recoverable in respect of previous years • is calculated using rates enacted or substantively enacted at the dates of the consolidated balance sheets in the countries where our subsidiaries and equity-accounted investees operate and generate taxable earnings • is the best estimate expected to be paid to (or recovered from) the taxation authorities	• is recognized using the liability method • is based on temporary differences between carrying amounts of assets and liabilities and their respective income tax bases • is determined using tax rates that have been enacted or substantively enacted by the dates of the consolidated balance sheets and are expected to apply when the related deferred income tax asset is realized or the deferred income tax liability is settled
Current and deferred income tax assets and liabilities are offset only if certain criteria are met.	
The realized and unrealized excess tax benefits from share-based compensation arrangements are recognized in contributed surplus as current and deferred tax, respectively.	

The final taxes paid, and potential adjustments to tax assets and liabilities, are dependent upon many factors including

- negotiations with taxation authorities in various jurisdictions;
- outcomes of tax litigation; and
- resolution of disputes arising from federal, provincial, state and local tax audits.

Deferred income tax is not accounted for

- with respect to investments in subsidiaries and equity-accounted investees where we are able to control the reversal of the temporary difference and that difference is not expected to reverse in the foreseeable future; and
- if arising from initial recognition of an asset or liability in a transaction, other than a business combination, that at the time of the transaction affects neither accounting nor taxable profit or loss.

Deferred tax assets are

- recognized to the extent it is probable future taxable profit will be available to use deductible temporary differences and could be reduced if projected earnings are not achieved or increased if earnings previously not projected become probable; and
- reviewed at each balance sheet date and amended to the extent that it is no longer probable that the related tax benefit will be realized.

Financial Instruments

Financial assets are measured at fair value (either through OCI or through profit or loss) or amortized cost depending on the objective of the business model for managing the instrument or group of instruments and the contractual terms of the cash flows.

For equity investments not held for trading, we may make an irrevocable election at initial recognition to recognize changes in fair value through OCI rather than profit or loss.

Financial instruments are classified and measured as follows:

Fair Value Classification	Fair Value Through Profit or Loss	FVTOCI	Amortized Cost
Instrument type	Cash and cash equivalents, derivatives, and certain equity investments not held for trading	Certain equity investments not held for trading for which an irrevocable election was made	Receivables, short-term debt, payables and accrued charges, long-term debt, lease liabilities, and other long-term debt instruments
Fair value gains and losses	Profit or loss	OCI	–
Interest and dividends	Profit or loss	Profit or loss	Profit or loss: effective interest rate
Impairment of assets	–	–	Profit or loss
Foreign exchange	Profit or loss	OCI	Profit or loss
Transaction costs	Profit or loss	OCI	Included in cost of instrument

Financial instruments are recognized at trade date when we commit to purchase or sell the asset. Financial assets are derecognized when the rights to receive cash flow from the investments have expired or we have transferred the rights to receive cash flow and all the risks and rewards of ownership have also been substantially transferred.

Derivatives are used to lock in exchange rates. For designated and qualified cash flow hedges

- the effective portion of the change in the fair value of the derivative is accumulated in OCI;
- when the hedged forecast transaction occurs, the related gain or loss is removed from AOCI and included in the cost of inventory or property plant and equipment;
- the hedging gain or loss included in the cost of inventory is recognized in earnings when the product containing the hedged item is sold or becomes impaired; and
- the ineffective portions of hedges are recorded in net earnings in the current period.

We assess whether our derivatives hedging transactions are expected to be or were highly effective, both at the hedge's inception and on an ongoing basis, in offsetting changes in fair values of hedged items.

Hedging Transaction	Measurement of Ineffectiveness	Potential Sources of Ineffectiveness
Foreign exchange	Comparison of the cumulative changes in fair value and the cumulative change in the fair value of a hypothetical derivative with terms based on the hedged forecast cash flows	Changes in • timing or amounts of forecasted cash flows • embedded optionality • our credit risk or the credit risk of a counterparty

Financial assets and financial liabilities are offset, and the net amount is presented in the consolidated balance sheets when we

- currently have a legally enforceable right to offset the recognized amounts; and
- intend either to settle on a net basis, or to realize the assets and settle the liabilities simultaneously.

Fair Value Measurements

Estimated fair values for financial instruments are designed to approximate amounts for which the instruments could be exchanged in a current arm's-length transaction between knowledgeable, willing parties. The valuation policies and procedures for financial reporting purposes are determined by our finance department.

Fair value measurements are categorized into different levels within a fair value hierarchy based on the degree to which the lowest level inputs are observable and their significance:

Level 1	Level 2	Level 3
Unadjusted quoted prices (in active markets accessible at the measurement date for identical assets or liabilities)	Quoted prices (in markets that are not active or based on inputs that are observable for substantially the full term of the asset or liability)	Prices or valuation techniques that require inputs that are both unobservable and significant to the overall measurement

Fair value estimates

- are at a point in time and may change in subsequent reporting periods due to market conditions or other factors;
- can be determined using multiple methods, which can cause values (or a range of reasonable values) to differ; and
- may require assumptions about costs/prices over time, discount and inflation rates, defaults, and other relevant variables.

Cash and Cash Equivalents

Highly liquid investments with a maturity of three months or less from the date of purchase are considered to be cash equivalents.

Receivables

Receivables from customers are recognized initially at fair value and subsequently measured at amortized cost less allowance for expected credit losses of receivables from customers.

Inventories

Inventories are valued monthly at the lower of cost and net realizable value. Costs are allocated to inventory using the weighted average cost method.

Net realizable value is based on:

Products and Raw Materials	Materials and Supplies
• selling price of the finished product (in ordinary course of business) less the estimated costs of completion and estimated costs to make the sale	• replacement cost

A writedown is recognized if the carrying amount exceeds net realizable value and may be reversed if the circumstances that caused it no longer exist. Various factors impact our estimates of net realizable value, including inventory levels, forecasted prices of key production inputs, global nutrient capacities, crop price trends, and changes in regulations and standards employed.

Vendors may offer various incentives to purchase products for resale. Vendor rebates and prepay discounts are accounted for as a reduction of the prices of the suppliers' products. Rebates based on the amount of materials purchased reduce cost of goods sold as inventory is sold. Rebates earned based on sales volumes of products are offset to cost of goods sold.

Rebates that are probable and can be reasonably estimated are accrued. Rebates that are not probable or estimable are accrued when certain milestones are achieved.

Estimation of rebates can be complex in nature as vendor arrangements are diverse. The amount of the accrual is determined by analyzing and reviewing historical trends to apply negotiated rates to estimated and actual purchase volumes. Estimated amounts accrued throughout the year could also be impacted if actual purchase volumes differ from projected volumes.

Property, Plant and Equipment

	Owned	Right-of-Use (Leased)
Description	• majority of our tangible assets are buildings, machinery and equipment used to produce or distribute our products and render our services	• primarily include railcars, marine vessels, real estate and mobile equipment
Measurement	• cost, which includes capitalized borrowing costs, less accumulated depreciation and any accumulated impairment losses • cost of major inspections and overhauls is capitalized • maintenance and repair expenditures that do not improve or extend productive life are expensed in the period incurred	• cost less accumulated depreciation and any accumulated impairment losses • lease payments are allocated between finance costs and a reduction of the liability, and discounted using the interest rate implicit in the lease, if available, or an incremental borrowing rate, being a rate that we would have to pay to borrow the funds required to obtain a similar asset, adjusted for term, security, asset value and the borrower's economic environment.
Depreciation method	• certain property, plant and equipment directly related to our Potash, Nitrogen and Phosphate segments uses units-of-production based on the shorter of estimates of reserves or service lives • pre-stripping costs uses units-of-production over the ore mined from the mineable acreage stripped • remaining assets uses straight-line	• straight-line over the shorter of the asset's useful life and the lease term
	Estimated useful lives, expected patterns of consumption, depreciation method and residual values are reviewed at least annually.	
Judgment/practical expedients	Judgment is required in determining • costs, including income or expenses derived from an asset under construction, that are eligible for capitalization; • timing to cease cost capitalization, generally when the asset is capable of operating in the manner intended by management, but also considering the circumstances and the industry in which the asset is to be operated, normally predetermined by management with reference to such factors as productive capacity; • the appropriate level of componentization (for individual components for which different depreciation methods or rates are appropriate); • repairs and maintenance that qualify as major inspections and overhauls; and • useful life over which such costs should be depreciated, which may be impacted by changes in our strategy, process or operations as a result of climate-change initiatives.	Judgment is required to determine whether a contract or arrangement includes a lease and if it is reasonably certain that an extension option will be exercised. We seek to maximize operational flexibility in managing our leasing activities by including extension options when negotiating new leases. Extension options are exercisable at our option and not by the lessors. In determining if a renewal period should be included in the lease term, we consider all relevant factors that create an economic incentive for us to exercise a renewal, including • the location of the asset and the availability of suitable alternatives, • the significance of the asset to operations, and • our business strategy. Estimation is used to determine the useful lives of ROU assets, the lease term and the appropriate discount rate applied to the lease payments to calculate the lease liability.

	Owned	Right-of-Use (Leased)
	Uncertainties are inherent in estimating reserve quantities, particularly as they relate to assumptions regarding future prices, the geology of our mines, the mining methods used, and the related costs incurred to develop and mine reserves. Changes in these assumptions could result in material adjustments to reserve estimates, which could result in impairments or changes to depreciation expense in future periods.	We have chosen to • include the use of a single discount rate for a portfolio of leases with reasonably similar characteristics, • not separate non-lease components and instead to account for lease and non-lease components as a single arrangement, and • use exemptions for short-term and low-value leases which allow payments to be expensed as incurred.
Other	Not applicable.	Lease agreements do not contain significant covenants; however, leased assets may be used as security for lease liabilities and other borrowings.

Goodwill and Intangible Assets

Goodwill is carried at cost, is not amortized, and represents the excess of the cost of an acquisition over the fair value of the Company's share of the net identifiable assets of the acquired subsidiary at the date of acquisition. Goodwill is allocated to a CGU or group of CGUs for impairment testing based on the level at which it is monitored by management, and not at a level higher than an operating segment. The allocation is made to the CGU or group of CGUs expected to benefit from the business combination in which the goodwill arose.

Intangible assets are generally measured at cost less accumulated amortization and any accumulated impairment losses. We use judgment to determine which expenditures are eligible for capitalization as intangible assets. Costs incurred internally from researching and developing a product are expensed as incurred until technological feasibility is established, at which time the costs are capitalized until the product is available for its intended use. Judgment is required in determining when technological feasibility of a product is established. Intangible assets with finite lives are amortized on a straight-line basis over their estimated useful lives. At least annually, the useful lives are reviewed and adjusted if appropriate.

Impairment of Long-Lived Assets

To assess impairment, assets are grouped at the smallest levels for which there are separately identifiable cash inflows that are largely independent of the cash inflows from other assets or groups of assets (this can be at the asset or CGU level).

At the end of each reporting period, we review conditions to determine whether there is any indication that an impairment exists that could potentially impact the carrying amounts of both our long-lived assets to be held and used (including property, plant and equipment, and investments), and our goodwill and intangible assets. When such indicators exist, impairment testing is performed. Additionally, goodwill is tested at least annually on October 1.

We review, at each reporting period, for possible reversal of the impairment for non-financial assets, other than goodwill.

Estimates and judgment involve

- identifying the appropriate asset, group of assets, CGU or groups of CGUs;
- determining the appropriate discount rate for assessing the recoverable amount;
- making assumptions about future sales, market conditions, terminal growth rates and cash flow forecasts over the long-term life of the assets or CGUs; and
- evaluating impacts of climate change to our strategy, processes and operations.

We cannot predict if an event that triggers impairment or a reversal of impairment will occur, when it will occur or how it will affect reported asset amounts. Asset impairment amounts previously recorded could be affected if different assumptions were used or if market and other conditions change. Such changes could result in non-cash charges materially affecting our consolidated financial statements.

Pension and Other Post-Retirement Benefits

Employee retirement and other defined benefit plans costs, including current and past service costs, gains or losses on curtailments and settlements, and remeasurements, are actuarially determined on a regular basis using the projected unit credit method.

When a plan amendment occurs before a settlement, we recognize past service cost before any gain or loss on settlement.

Our discount rate assumptions are impacted by

- the weighted average interest rate at which each pension and other post-retirement plan liability could be effectively settled at the measurement date;
- country specific rates; and
- the use of a yield curve approach based on the respective plans' demographics, expected future pension benefits and medical claims. Payments are measured and discounted to determine the present value of the expected future cash flows. The cash flows are discounted using yields on high-quality AA-rated non-callable bonds with cash flows of similar timing where there is a deep market for such bonds. Where we do not believe there is a deep market for such bonds (such as for terms in excess of 10 years in Canada), the cash flows are discounted using a yield curve derived from yields on provincial bonds rated AA or better to which a spread adjustment is added to reflect the additional risk of corporate bonds.

Net actuarial gains or loss incurred during the period for defined benefit plans are closed out to retained earnings at each period-end.

Asset Retirement Obligations and Accrued Environmental Costs

Asset retirement obligations and accrued environmental costs include

- reclamation and restoration costs at our potash and phosphate mining operations, including management of materials generated by mining and mineral processing, such as various mine tailings and gypsum;
- land reclamation and revegetation programs;
- decommissioning of underground and surface operating facilities;
- general clean-up activities aimed at returning the areas to an environmentally acceptable condition; and
- post-closure care and maintenance.

We consider the following factors as we estimate our provisions:

- environmental laws and regulations and interpretations by regulatory authorities, including updates on climate change, could change or circumstances affecting our operations could change, either of which could result in significant changes to current plans;
- the nature, extent and timing of current and proposed reclamation and closure techniques in view of present environmental laws and regulations;
- appropriate technical resources, including outside consultants, assist us in developing specific site closure and post-closure plans in accordance with the jurisdiction requirements; and
- timing of settlement of the obligations, which is typically correlated with mine life estimates except for certain land reclamation programs.

It is reasonably possible that the ultimate costs could change in the future and that changes to these estimates could have a material effect on our consolidated financial statements. We review our estimates for any changes in assumptions at the end of each reporting period.

We recognized contingent liabilities related to our business combinations or acquisitions, which represent additional environmental costs that are present obligations although cash outflows of resources are not probable. These contingent liabilities are subsequently measured at the higher of the amount initially recognized and the amount that would be recognized if the liability becomes probable.

Share Capital

Common shares are classified as equity. Incremental costs directly attributable to the issuance of common shares are recognized as a deduction from equity, net of any tax effects. When we repurchase our own common shares, share capital is reduced by the average carrying value of the shares repurchased. The excess of the purchase price over the average carrying value is recognized as a deduction from retained earnings. If the average carrying value of the shares repurchased is less than the average carrying value of the shares in share capital, the excess is recognized as an addition to share capital. Shares are cancelled upon repurchase.

Restructuring Charges

Plant shutdowns, sales of business units or other corporate restructurings may trigger restructuring charges. The provision is based on the best estimate of a detailed formal plan, which includes determining the incremental costs for employee termination, contract termination and other exit costs.

Business Combinations

Purchase price allocation involves judgment in identifying assets acquired and liabilities assumed, and estimation of their fair values. Key assumptions include discount rates and revenue growth rates specific to the acquired assets or liabilities assumed. We performed a thorough review of all internal and external sources of information available on circumstances that existed at the acquisition date. We also engaged independent valuation experts on certain acquisitions to assist in determining the fair value of certain assets acquired and liabilities assumed and related deferred income tax impacts. To determine fair values, we generally use the following valuation techniques:

Account	Valuation Technique and Judgments Applied
Property, plant and equipment	Market approach for land and certain types of personal property: sales comparison that measures the value of an asset through an analysis of sales and offerings of comparable assets. Replacement costs for all other depreciable property, plant and equipment: measures the value of an asset by estimating the costs to acquire or construct comparable assets and adjusts for age and condition of the asset.
Intangible assets	Income approach – multi-period excess earnings method: measures the value of an asset based on the present value of the incremental after-tax cash flows attributable to the asset after deducting contributory asset charges ("CACs"). Allocation of CACs is a matter of judgment and based on the nature of the acquired businesses' operations and historical trends. We considered several factors in determining the fair value of customer relationships, such as customers' relationships with the acquired company and its employees, the segmentation of customers, historical customer attrition rates, and revenue growth.
Other provisions and contingent liabilities	Decision-tree approach of future costs and a risk premium to capture the compensation sought by risk-averse market participants for bearing the uncertainty inherent in the cash flows of the liability.

For each business combination, we elect to measure the non-controlling interest in the acquired entity either at fair value or at the proportionate share of the acquiree's identifiable net assets. Foreign exchange hedge gains or losses that we designated a cash flow hedge are included in the consideration. The gain or loss from the cash flow hedge is deferred in OCI and subsequently recorded as an adjustment to goodwill when the business combination occurs.

Transaction costs are recorded in integration and restructuring related costs in other (income) expenses.

Standards, Amendments and Interpretations Effective and Applied

The IASB and IFRS Interpretations Committee ("IFRIC") has issued certain standards and amendments or interpretations to existing standards that were effective, and we have applied.

In 2022, we have adopted the following amendments and annual improvements with no material impact on our consolidated financial statements:

- Reference to the Conceptual Framework (Amendments to IFRS 3)
- Property, Plant and Equipment: Proceeds before Intended Use (Amendments to IAS 16)
- Onerous Contracts – Cost of Fulfilling a Contract (Amendments to IAS 37)
- Annual Improvements to IFRS Standards 2018–2020 (IFRS 16, IFRS 9, IFRS 1, IAS 41)

Standards, Amendments and Interpretations Not Yet Effective and Not Applied

The IASB and IFRIC have issued the following standards, amendments or interpretations to existing standards that were not yet effective and not applied as at December 31, 2022.

The following amendments and amended standards will be adopted in 2023 and are not expected to have a material impact on our consolidated financial statements:

- Deferred Tax related to Assets and Liabilities arising from a Single Transaction (IFRS 1, IAS 12)
- Disclosure of Accounting Policies (Amendments to IAS 1 and IFRS Practice Statement 2)
- Definition of Accounting Estimates (Amendments to IAS 8)
- IFRS 17 Insurance Contracts
- Amendments to IFRS 17

The following amendments are being reviewed to determine the potential impact on our consolidated financial statements:

- Lease Liability in a Sale and Leaseback (Amendments to IFRS 16)
- Classification of liabilities as current or non-current (Amendments to IAS 1)

Terms & Definitions

Terms

AECO	Alberta Energy Company, Canada
Argus	Argus Media group, UK
Bloomberg	Bloomberg Finance L.P., USA
CDP Climate	CDP Worldwide, England
CDP Water	CDP Worldwide, England
CRU	CRU International limited, UK
ESG	Environmental, social and governance
FTSE Russell	FTSE International Limited, England
ISS Quality Scores	Institutional Shareholder Services Inc., USA
Moody's	Moody's Corporation (NYSE: MCO), USA
MSCI ESG Rating	MSCI Inc., USA
NYMEX	New York Mercantile Exchange, USA
NYSE	New York Stock Exchange, USA
S&P/S&P Global Corporate Sustainability Assessment	S&P Global Inc., USA
TSX	Toronto Stock Exchange, Canada
USDA	United States Department of Agriculture, USA
CAD	Canadian dollar
USD	United States dollar
AUD	Australian dollar

Scientific Terms

Potash	KCl	potassium chloride, 60–63.2% K_2O (solid)
Nitrogen	CO_2e	carbon dioxide equivalent
	DEF	diesel exhaust fluid
	ESN®	environmentally smart nitrogen, 44% nitrogen
	NH_3	ammonia (anhydrous), 82.2% N (liquid)
	N_2O	nitrous oxide
	UAN	nitrogen solutions, 28–32% N (liquid)
Phosphate	AS	ammonium sulfate (solid)
	DAP	diammonium phosphate, 46% P_2O_5 (solid)
	MAP	monoammonium phosphate, 52% P_2O_5 (solid)
	MGA	merchant grade acid, 54% P_2O_5 (liquid)
	MST	micronized sulfur technology, P + S
	P_2O_5	phosphorus pentoxide
	SPA	superphosphoric acid, 70% P_2O_5 (liquid)

Product Measures

K_2O tonne	Measures the potassium content of products having different chemical analyses
N tonne	Measures the nitrogen content of products having different chemical analyses
P_2O_5 tonne	Measures the phosphorus content of products having different chemical analyses
Product tonne	Standard measure of the weights of all types of potash, nitrogen and phosphate products

Definitions

Low-carbon ammonia	Ammonia made with direct GHG emissions typically reduced by approximately 60 percent but up to 80 percent, produced by primarily using carbon capture, utilization and storage ("CCUS") or other low-emission production technologies; this definition does not include end product use.
Brownfield	New project expanding or developing an existing facility or operation.
Community investment	Represents cash disbursements, matching of employee gifts and in-kind contributions of equipment, goods and services, and employee volunteerism (on corporate time).
Clean ammonia	Ammonia made with direct GHG emissions reduced by at least 90 percent, produced from hydrogen obtained using the next generation of ammonia production technology, such as auto-thermal reforming or water electrolysis with renewable power; this definition does not include end product use.
Cumulative annual growth rate ("CAGR")	Represents the rate of return that would be required for an investment to grow from its beginning balance to its ending balance assuming the profits were reinvested at the end of each year of the investment's lifespan.
COVID-19	COVID-19 coronavirus pandemic.
Environmental incidents	Number of incidents includes non-permitted release quantities that equal or exceed the US Comprehensive Environmental Response, Compensation, and Liability Act limits in a 24- hour period at all non-potash facilities; in potash facilities any non- permitted release that equals or exceeds Saskatchewan release limits in a 24- hour period (based on the Saskatchewan Environmental Code); non-compliance incidents that exceed $10,000 in costs to reach compliance; or enforcement actions with fines exceeding $1,000.
Greenfield	New project on a previously undeveloped site.
Greenhouse gas ("GHG")	Gas that contributes to the greenhouse effect by absorbing infrared radiation.
Latin America	South America, Central America, Caribbean and Mexico.
Lost-time injury frequency	Total lost-time injuries for every 200,000 hours worked for all Nutrien employees, contractors and others on site. Calculated as the total lost-time injuries multiplied by 200,000 hours worked divided by the actual number of hours worked.
Merger	The merger of equals transaction between PotashCorp and Agrium completed effective January 1, 2018, pursuant to which PotashCorp and Agrium combined their businesses pursuant to a statutory plan of arrangement under the Canada Business Corporations Act and became wholly owned subsidiaries of Nutrien Ltd.
Mmt	Million metric tonnes.
North America	Canada and the US.
Offshore	All markets except Canada and the US.
Serious injury and fatality	A work-related fatality or life-altering injury/illness experienced by an employee or directly supervised contractor conducting work on behalf of Nutrien.
Scope 1	Direct greenhouse gas emissions produced by Nutrien owned or controlled facilities.
Scope 2	Greenhouse gas emissions resulting from the generation of purchased or acquired electricity, heating, cooling and steam consumed by Nutrien owned or controlled facilities.
Scope 3	Indirect greenhouse gas emissions not included in Scope 1 or Scope 2 emissions occurring as a consequence of the activities of Nutrien, from sources not owned or controlled by Nutrien, including both upstream and downstream emissions.
Total employee turnover rate	The number of permanent employees who left the Company due to voluntary and involuntary terminations, including retirements and deaths, as a percentage of average permanent employees for the year.
Total recordable injury frequency	Total recordable injuries for every 200,000 hours worked for all Nutrien employees, contractors and others on site. Calculated as the total recordable injuries multiplied by 200,000 hours worked divided by the actual number of hours worked.
Total shareholder return	Return on investment in Nutrien shares from the time the investment is made based on two components: (1) growth in share price and (2) return from reinvested dividend income on the shares.
Voluntary employee turnover	The number of permanent employees who left the Company due to voluntary terminations as a percentage of average permanent employees for the year. Includes voluntary retirements and resignations.

Shareholder Information

Dividends

Dividend amounts paid to shareholders resident in Canada are adjusted by the exchange rate applicable on the dividend record date. Dividends are normally paid in January, April, July and October with record dates normally set approximately three weeks in advance of the payment date. Future cash dividends will be paid out of, and are conditioned upon, the Company's available earnings. Shareholders who wish to have their dividends deposited directly to their bank accounts should contact the transfer agent and registrar, Computershare Investor Services Inc.

Ownership

On February 16, 2023, there were 870 holders of record of the Company's common shares.

Common Share Prices

The Company's common shares are traded on the Toronto Stock Exchange and the New York Stock Exchange. Nutrien is included in the S&P/TSX 60 and the S&P/TSX Composite indices.

Offices

Nutrien's registered head office is:

Suite 1700, 211 19th Street East
Saskatoon, Saskatchewan
Canada S7K 5R6

We also have corporate offices at:

13131 Lake Fraser Drive SE
Calgary, Alberta
Canada T2J 7E8

5296 Harvest Lake Drive
Loveland, Colorado
US 80538

Investor Relations

Investor Relations Department

Email investors@nutrien.com

Phone (403) 225-7451

Transfer Agent

You can contact Computershare Investor Services Inc., the Company's transfer agent, as follows:

Phone 1-888-847-9773
(toll-free within Canada and the US)
1-514-982-7555
(from any country other than Canada and the US)

By Fax 1-888-453-0330
(all countries)

By Mail Computershare
100 University Ave,
8th Floor, North Tower
Toronto, ON M5J 2Y1

Internet Access your registered account on the Investor Centre website:
www.investorcentre.com

NYSE Corporate Governance

The certifications required by Section 302 of the Sarbanes-Oxley Act of 2002 are filed as exhibits to our 2022 Annual Report on Form 40-F.

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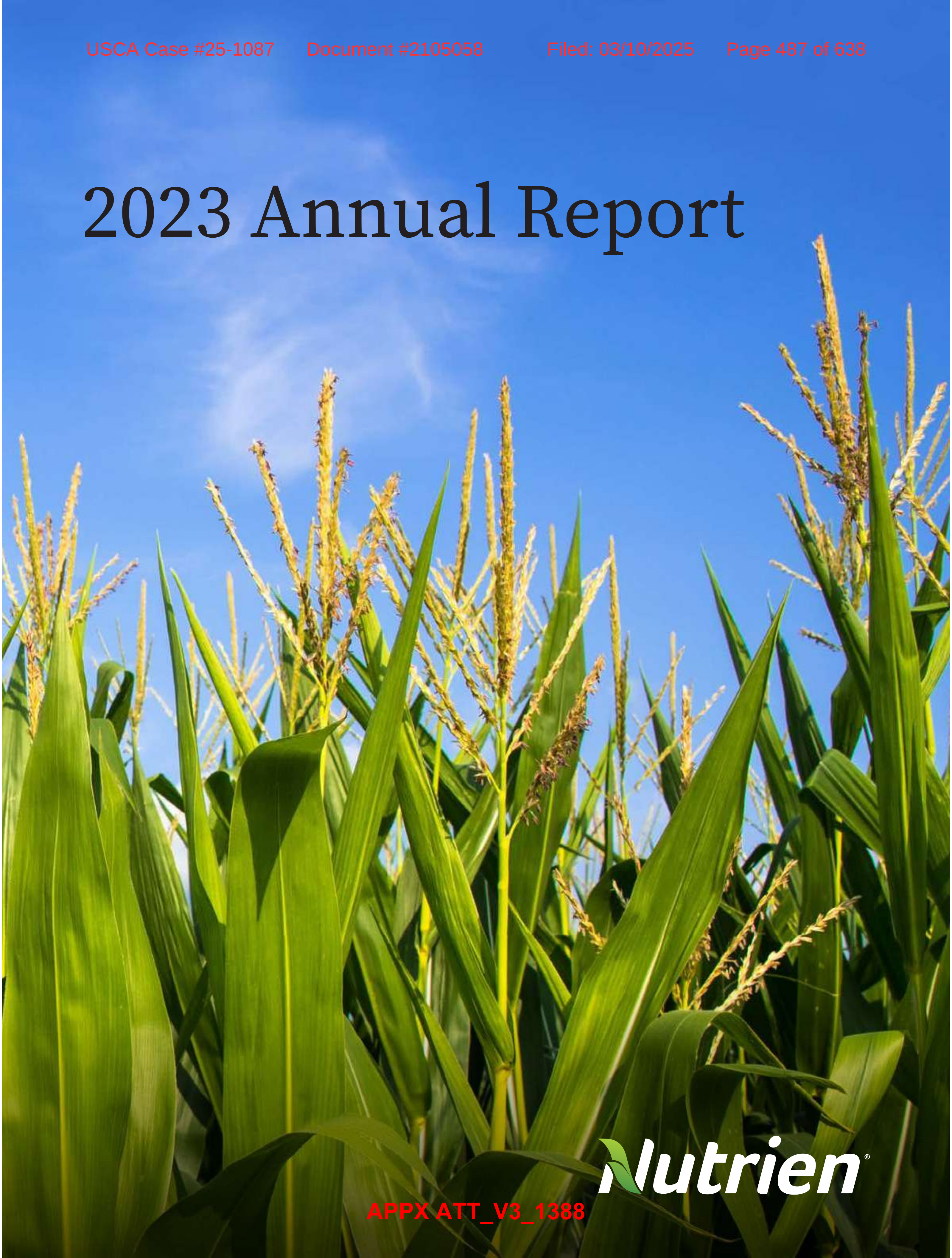
2023 Annual Report



Nutrien

Contents

You can find this report and information on Nutrien on our website at **nutrien.com**. More detailed information on our sustainability strategy and performance is provided on our website at **nutrien.com/sustainability**.

The Overview contains certain non-GAAP financial measures, which do not have a standard meaning under IFRS, and other financial measures including

- Adjusted net earnings per share
- Adjusted EBITDA
- Return on invested capital ("ROIC")
- Adjusted net debt

For definitions, further information and reconciliation of these measures, to the most directly comparable measures under IFRS, see the "Non-GAAP financial measures" section. See the "Other financial measures" and "Terms and definitions" sections for definitions, abbreviations and terms used in this annual report.

Why Nutrien

Nutrien is a leading provider of crop inputs and services, helping to safely and sustainably feed a growing world. We operate a world-class integrated network of production, distribution and ag retail facilities that positions us to efficiently serve the needs of growers. Our Nutrien Ag Solutions ("Retail") business enhances the stability of earnings and our low-cost fertilizer production assets have historically generated significant cash flow through the cycle. We take a balanced and disciplined approach to capital allocation, prioritizing investments that strengthen the advantages of our integrated business and returning meaningful capital to our shareholders.

1 | Advantaged position across the ag value chain

2 | Proven financial strength and stability

3 | Provider of sustainable agriculture solutions

Letter from our President and CEO

By 2050, the world's population is expected to reach nearly 10 billion people and global grain and oilseed demand is projected to exceed 5 billion tonnes on an annual basis. The amount of arable land per person is estimated to decline by 15 percent over this period, highlighting the challenge that lies ahead to produce enough nutritious food to sustain this population while preserving the world's resources for generations to come.

Ken Seitz
President and Chief Executive Officer

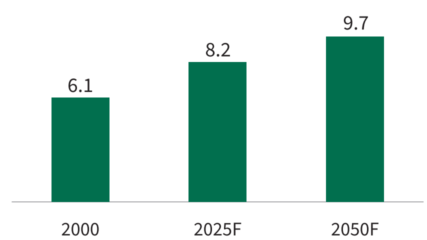
Feeding the future
Nutrien's purpose of Feeding the Future reflects the vital role we play in helping growers safely and sustainably feed a growing world. We provide products and services that increase crop productivity while improving environmental performance, important outcomes that we believe must be achieved in tandem. Through the collective expertise of our nearly 26,000 employees and the unique advantages of our world-class integrated network, we strive to provide a more profitable, sustainable and secure future for our stakeholders.

Navigated through period of unprecedented market volatility
We operate with a long-term mindset but need to be flexible and responsive to our near-term operating environment. The agriculture industry has come through a period of unprecedented market volatility since early 2022 driven by a series of global geopolitical conflicts, supply chain disruptions and shifting buying patterns. These unique events have impacted our performance and resulted in adjustments to our strategic priorities.

In 2022, Nutrien generated record earnings and operating cash flows as prices for agriculture and crop input products rose in response to supply-side shocks. We allocated free cash flow to advance strategic growth initiatives and increased share repurchases, deploying capital in areas that we believed would create the greatest long-term value for our shareholders.

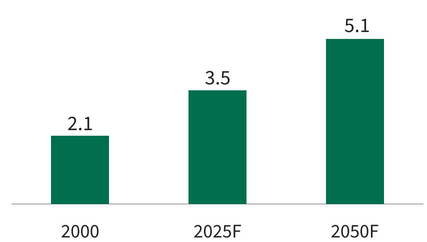
Crop input market fundamentals shifted in 2023 as supply chains adapted and higher cost inventory worked its way through the channel, resulting in lower fertilizer selling prices and Retail gross margins compared to the record prior year. As the year progressed, we saw increased market stability and stronger fertilizer demand in North America, supported by improved grower affordability and lower channel inventories. Fertilizer demand in key offshore markets also increased in the second half of 2023, however the level of market stabilization varied by product and geography.

Global population growth [1]
(billions of people)



Source: United Nations
1 Forecast as of January 30, 2024.

Global grain and oilseed demand [1]
(billions of tonnes)



Source: USDA
1 Forecast as of January 30, 2024. Based on trend production of barley, corn, millet, mixed grains, oats, oil palm, canola/rapeseed, soybean, sunflower, rice, rye, sorghum and wheat.

$5.1B

cash provided by operating activities in 2023

$2.1B

returned to shareholders through share repurchases and dividends in 2023

Nutrien delivered adjusted EBITDA[1] of $6.1 billion (net earnings of $1.3 billion) in 2023, below our initial expectations for the year. In response to the change in market conditions, we took a number of actions to reduce controllable costs and enhance free cash flow. This included a pause of our potash ramp-up and suspension of work on our Geismar clean ammonia project. These decisions, along with other operational efficiency initiatives, lowered our 2023 planned capital expenditures by $300 million and operating expenses by $100 million.

Operating cash flow of $5.1 billion was supported by a reduction in non-cash working capital in Retail, one of the counter-cyclical advantages of our integrated business. We maintained a balanced and disciplined approach to capital allocation, investing $2.7 billion to sustain and enhance our assets and returned $2.1 billion to shareholders through dividends and share repurchases. Since the beginning of 2018, we have increased our dividend per share by 35 percent and repurchased 23 percent of our outstanding shares.

Strengthened advantages of our integrated business

As we reflect on the past year, I am proud of the progress we made on a number of strategic initiatives that strengthened our core business, positioned the Company for growth and advanced our key sustainability priorities.

In Retail, we continue to develop new and innovative ways to serve the needs of our grower customers. A great example of this is our proprietary products business. These high-value products enhance yield and environmental performance for the grower, while supporting higher margins for Nutrien.

Our global proprietary products portfolio contributed $1.0 billion in gross margin in 2023 and we increased sales and margins from our plant nutritional and biostimulant product lines. Gross margin for these nutritional products has grown at a compound annual growth rate of 15 percent over the last five years. We plan to continue to invest in our proprietary product business through differentiated offerings and expanded manufacturing capacity.

In late 2022, we established a global commercial organization with a single point of accountability for delivering best-in-class customer service, driving supply chain efficiencies, and leading margin optimization opportunities across our integrated network. The commercial team executed on a number of opportunities that supported netbacks in a volatile market environment and record sales volumes to North American fertilizer customers in the second half of 2023. This included capturing incremental value by delivering record potash volumes through Nutrien Ag Solutions in North America, as well as more than doubling sales of MAP+MST, our specialty phosphate fertilizer offering.

1 This is a non-GAAP financial measure. See the “Non-GAAP Financial Measures” section.

$1.0B

gross margin from Retail proprietary products in 2023

40%

increase in annual potash ore tonnes cut using autonomous mining technology

We have a low-cost, flexible, six-mine potash network with access to the best geology in the world. In 2023, we increased our annual potash ore tonnes cut using autonomous mining technology by 40 percent, improving the safety and efficiency of our operations. We announced the pause of our ramp-up to 18 million tonnes while continuing to retain operational flexibility and our low-cost position, preserving the ability to respond to opportunities when there are disruptions to global potash supply or surges in demand.

Nutrien is an industry leader in developing low-carbon nitrogen production for integration into our value chain. In 2023, we completed our GHG Phase 1 abatement projects, which was a multi-year capital program that will be a key contributor to reducing our greenhouse gas emissions. We also completed brownfield expansion projects at our Geismar nitrogen facility and major maintenance turnarounds at our Geismar and Borger sites that will support increased operating rates going forward.

Nothing is more important than the safety, health and wellness of our employees, our contractors and the communities we serve. While we achieved our lowest recordable injury rate ever across our global operations, regretfully our safety performance in 2023 fell short of our expectations. This past year we experienced a loss that deeply impacted our organization – the tragic passing of one of our US Retail co-workers. This devastating loss reminds us of the importance of our relentless pursuit of safety. We are committed to doing better and continue to take steps to prevent similar incidents from happening again. It is critical that we continue to prioritize the training, processes and systems that keep our people and communities safe.

Positioned for growth in the future

Looking at the year ahead, agriculture fundamentals remain supportive with global grain stocks-to-use ratios at historically low levels. Crop prices have declined from historically high levels in 2022 but lower crop input prices have resulted in improved affordability and demand.

We expect gross margins for our Retail business to improve across all product lines as input prices stabilize and grower purchasing behavior normalizes. Global potash shipments are projected to increase to 68 to 71 million tonnes in 2024 as demand continues to recover towards trend levels. Constraints on global energy and nitrogen supply continue to provide a positive backdrop for our low-cost nitrogen assets. We expect to deliver higher fertilizer sales volumes supported by increased global fertilizer demand and improved operating rates at our nitrogen and phosphate facilities.

Over the longer-term, we believe structural market shifts will be supportive of higher fertilizer benchmark prices compared to historical 10-year average levels. This view is driven by the expectation for continued tightness in global crop markets, higher energy prices and other inflationary impacts on the global cost curve.

Beyond these market factors, we are prioritizing initiatives within our control that enhance the quality of earnings,

free cash flow and return on capital. We intend to maintain a balanced and disciplined approach to capital allocation and have reduced planned capital expenditures by approximately $400 million in 2024 compared to the prior year.

We are projecting investment capital of $500 million in 2024, with approximately half of this total associated with initiatives that support organic growth in our core Retail geographies. This includes investments that expand our proprietary products portfolio, drive network optimization and enhance our digital capabilities.

The prospects for agriculture in Brazil remain positive and it remains an important crop input market for Nutrien. In the near term, we will continue to focus on integration of our recent acquisitions and optimization of our cost structure in this market.

The focus in our fertilizer operations is to maintain a low-cost position and drive further efficiencies through potash mine automation and reliability improvements at our nitrogen facilities. We expect to achieve more than 1 million tonnes of annual nitrogen volume growth through the completion of high-return brownfield expansion projects and reliability initiatives over the next few years. Additionally, we have capability to deliver an additional 1 to 2 million tonnes of potash per year compared to 2023 levels as demand for potash grows.

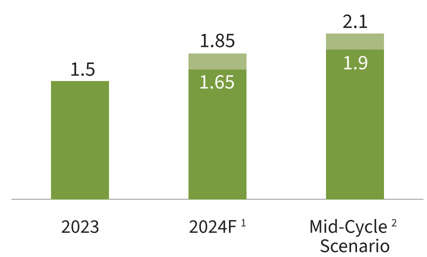
Across our business, we continue to build strong relationships with our customers, partners, suppliers, and the communities we serve, and will utilize the advantages of our integrated business and position the Company to deliver long-term value for our shareholders.

On behalf of the Board and our management team, I want to thank everyone who played a part in our successes in 2023 and especially our employees for your tireless effort as we work together to safely and sustainably Feed the Future.

Ken Seitz
President and Chief Executive Officer
February 22, 2024

Retail adjusted EBITDA [1,2]

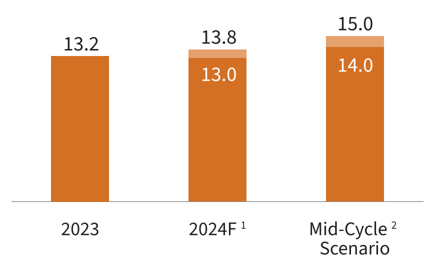
(US$ billions)



1 Guidance provided in our news release dated February 21, 2024.
2 See the "Forward-looking statements" section.

Potash manufactured sales volumes [1,2]

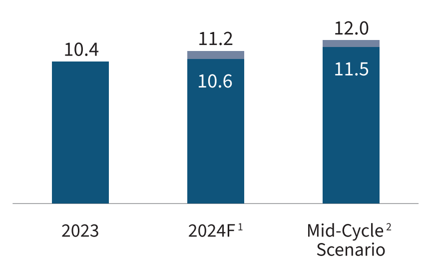
(millions of tonnes KCl)



1 Guidance provided in our news release dated February 21, 2024.
2 See the "Forward-looking statements" section.

Nitrogen manufactured sales volumes [1,2]

(millions of tonnes)



1 Guidance provided in our news release dated February 21, 2024.
2 See the "Forward-looking statements" section.

Performance highlights

Nutrien's results were impacted by unprecedented volatility in global crop input markets over the past two years. Net earnings and adjusted EBITDA decreased in 2023 compared to the record results in 2022 due to lower selling prices across all segments and lower Retail earnings. We generated $5.1 billion in cash from operating activities, invested $2.7 billion to sustain and enhance our assets, and returned $2.1 billion of cash to our shareholders through dividends and share repurchases in 2023. We continued to invest in key initiatives to reduce our total Scope 1 and 2 greenhouse gas ("GHG") emissions.

Years ended December 31

(in millions of US dollars, except as otherwise noted)	2023	2022	2021
Financial performance			
Sales	29,056	37,884	27,712
Gross margin	8,474	15,424	9,409
Net earnings	1,282	7, 687	3,179
Diluted net earnings per share (US dollars)	2.53	14.18	5.52
Adjusted net earnings per share [1] (US dollars)	4.44	13.19	6.23
Adjusted EBITDA [1]	6,058	12, 170	7,126
Retail adjusted EBITDA	1,459	2, 293	1,939
Potash adjusted EBITDA	2,404	5, 769	2,736
Nitrogen adjusted EBITDA	1,930	3, 931	2,308
Phosphate adjusted EBITDA	470	594	540
Cash provided by operating activities	5,066	8, 110	3,886
Cash used in investing activities	2,958	2,901	1,807
Capital expenditures	2,671	2, 475	1,884
Cash used for dividends and share repurchases [2]	2,079	5, 551	2,080
Return on invested capital [1]	10%	26%	15%
Adjusted net debt/Adjusted EBITDA [3]	1.9x	0.9x	1.4x
Non-financial performance [4]			
Scope 1 and 2 GHG emissions (Mmt CO_2e)	12.2	12.8	13.8
CO_2 captured and sold (Mmt)	1.0	1.1	1.1
Sustainably engaged acres (millions)	2	1	n/m
Lost-time injury frequency [5]	0.24	0.24	0.27
Proportion of women in senior leadership [5]	23%	21%	21%
Community investment	23	33	19

1 This is a non-GAAP financial measure. See the "Non-GAAP Financial Measures" section. Additional information relating to 2021 is contained in the "Appendix - Non-IFRS Financial Measures" sections of Nutrien's MD&A dated February 17, 2022 for the year ended December 31, 2021, which information is incorporated by reference herein. Such MD&A are available on SEDAR+ at sedarplus.ca.
2 This is a supplementary financial measure. See the "Other Financial Measures" section.
3 This is a capital management financial measure that includes non-GAAP components. See the "Non-GAAP Financial Measures" and "Other Financial Measures" sections.
4 These are non-financial measures. See the "Terms & Definitions" section.
5 Frequency based on every 200,000 hours worked.

Sustainability highlights

Nutrien is committed to delivering results for our stakeholders and pursuing our purpose of Feeding the Future with strategic targets and goals that address our key sustainability risks and opportunities. As our operating environment evolves, we continue to refine our approach through collaboration, innovation and continuous improvement.

2 million sustainably engaged acres

In 2023, we measured, documented and calculated outcomes on 2 million sustainably engaged acres in North America, South America and Australia. We continue to provide growers with whole-acre solutions that support sustainable and productive agriculture and aim to deliver improved environmental outcomes.

Supporting our 2030 Commitment to enable growers to adopt sustainable and productive agricultural products and practices on 75 million acres globally

GHG phase 1 completed

In 2023, we completed our GHG Phase 1 abatement program, which included a number of nitrous oxide ("N_2O") abatement projects, energy and emission efficiency upgrades, and tied in our second ammonia plant at our Redwater site to the Alberta Carbon Trunk Line to allow additional carbon dioxide ("CO_2") to be permanently sequestered.

Supporting our 2030 Commitment to achieve at least a 30 percent intensity reduction in GHG emissions (Scope 1 and 2) per tonne of our products produced, from a baseline year of 2018

Verified carbon offsets and insets

In 2023, we enabled emissions reductions on 900 thousand sustainably engaged acres in North America, working with growers and collaborating with 15 suppliers and downstream partners. We established a validated pathway and verified our first GHG insets in Canada and verified GHG offsets and insets in the US, based on grower data.

Supporting our 2030 Commitment to launch and scale a comprehensive Carbon Program, empowering growers and our industry to accelerate climate-smart agriculture and soil carbon sequestration while rewarding growers for their efforts

1.2 Mmt low-carbon ammonia

Our near-term focus is on using carbon capture, utilization and storage ("CCUS") infrastructure, and growing our low-carbon ammonia production. As of the end of 2023, Nutrien has annual production capability of 1.2 million tonnes of low-carbon ammonia at our Geismar, Redwater and Joffre nitrogen facilities.

Supporting our 2030 Commitment to invest in new technologies and pursue the transition to low-carbon fertilizers, including low-carbon and clean ammonia

Global Sustainability Report

For more information on our 2030 sustainability commitments and targets, please refer to our Global Sustainability Report expected to be published in March 2024, available on our website at **nutrien.com**.

Management's discussion & analysis

The following management's discussion and analysis ("MD&A") is the responsibility of management and is dated as of February 22, 2024.

The Board of Directors ("Board") of Nutrien carries out its responsibility for review of this disclosure principally through its Audit Committee, comprised exclusively of independent directors. The Audit Committee reviews and, prior to its publication, recommends to the Board approval of this disclosure. The Board has approved this disclosure. The term "Nutrien" refers to Nutrien Ltd. and the terms "we", "us", "our", "Nutrien" and "the Company" refer to Nutrien and, as applicable, Nutrien and its direct and indirect subsidiaries on a consolidated basis. This MD&A is based on the Company's audited consolidated financial statements for the year ended December 31, 2023 ("consolidated financial statements") based on International Financial Reporting Standards ("IFRS") as issued by the International Accounting Standards Board, unless otherwise stated.

This MD&A contains certain non-GAAP financial measures and ratios, which do not have a standard meaning under IFRS and, therefore, may not be comparable to similar measures presented by other issuers. Such non-GAAP financial measures and ratios include

- Adjusted EBITDA
- Adjusted net earnings and adjusted net earnings per share
- Gross margin excluding depreciation and amortization per tonne – manufactured
- Potash controllable cash cost of product manufactured per tonne
- Ammonia controllable cash cost of product manufactured per tonne
- Retail adjusted average working capital to sales and Retail adjusted average working capital to sales excluding Nutrien Financial
- Nutrien Financial adjusted net interest margin
- Retail cash operating coverage ratio
- Return on invested capital ("ROIC")
- Adjusted net debt

For definitions, further information and reconciliation of these measures to the most directly comparable measures under IFRS, see the "Non-GAAP financial measures" and "Other financial measures" sections.

Also see the cautionary statement in the "Forward-looking statements" section.

All references to per share amounts pertain to diluted net earnings (loss) per share. Financial data in this annual report is stated in millions of US dollars, which is the functional currency of Nutrien and the majority of its subsidiaries, unless otherwise noted.

Information that is not meaningful is indicated by n/m. Information that is not applicable is indicated by n/a. See the "Other financial measures" and "Terms and definitions" sections for definitions, abbreviations and terms used in this annual report including the MD&A.

Additional information relating to Nutrien (which, except as otherwise noted, is not incorporated by reference herein), including our Annual Information Form for the year ended December 31, 2023, can be found on SEDAR+ at sedarplus.ca and on EDGAR at sec.gov. The Company is a foreign private issuer under the rules and regulations of the US Securities and Exchange Commission (the "SEC").

The information contained on or accessible from our website or any other website is not incorporated by reference into this MD&A or any other report or document we file with or furnish to applicable Canadian or US securities regulatory authorities.

Our approach to annual reporting

Our goal is to communicate how we evaluate the opportunities and challenges in our operating environment, which shape our approach to setting strategy, managing risk and governing our actions. The priorities of our key stakeholders impact the way we approach long-term value creation, including addressing key sustainability priorities. We continue to integrate sustainability-related information into our corporate reporting framework, including reporting our Scope 1 and 2 GHG emissions, in this annual report.

01

Our company

Outlines who we are as a company, where we operate, how we create value and describes each of our operating segments

02

Operating environment

Defines factors and trends that influence the environment we operate in and outlook for 2024

03

Strategy

Describes our corporate strategy and how each of our operating segments is supporting that strategy

04

Governance

Describes our key corporate governance principles and risk management process

05

Key enterprise risks

Outlines the key risks that could affect our performance and our future operations

06

Results

Highlights our financial results for the year 2023 and guidance for 2024

01 Our company

Alberta, Canada

Wheat is a staple food for 35 percent of the world's population. Canada is a top exporter of wheat to approximately 60 countries worldwide. Nutrien operates 10 fertilizer production facilities in Western Canada and serves growers from our 275 Retail selling locations on the Canadian prairies.

How we create value

Our integrated business provides a number of advantages compared to our competitors, including operational, financial and sustainability opportunities. We continue to explore ways to further enhance the capabilities of our business to capture additional benefits across the agriculture value chain.

1 | Advantaged position across the ag value chain

Our integrated business provides competitive advantages to optimize operations, transportation and logistics, increase supply chain efficiencies, support volume growth, and be the key connection with the grower.

World-class production assets

26Mmt

NPK manufactured sales volumes in 2023

~2,000

proprietary products

Global supply chain

~460

wholesale fertilizer distribution points

>1,000

crop input suppliers

Leading ag retail network

>2,000

Retail selling locations across North America, South America and Australia

>4,000

crop consultants

2 | Proven financial strength and stability

Our diversified Retail business enhances the stability of our earnings base and our low-cost fertilizer production assets have historically generated significant cash flow, providing the ability to invest in our business and return meaningful capital to our shareholders.

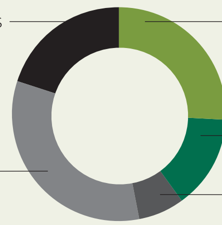
Substantial cash generation

$4.8B

annual average cash provided by operating activities (2019-2023)

Balanced approach to capital allocation (2019-2023)

(percent)



3 | Provider of sustainable agriculture solutions

Positioned to drive long-term value creation through integration of sustainability initiatives, from fertilizer production to grower practices in the field.

Carbon sequestration

400K

tonnes CO_2 permanently sequestered from our operations in 2023

Sustainability program

900K

sustainable agriproduct program acres

Collaborative partnerships

Value chain collaborator

to advance sustainable agriculture

Global profile

Our world-class fertilizer manufacturing assets are primarily located in North America, with access to high-quality resources, lower cost inputs and an extensive distribution network to efficiently supply our customers. Our Retail business serves growers in key agricultural markets in North America, South America and Australia.

R | Retail	K | Potash	N | Nitrogen	P | Phosphate
$19.5B Net sales [1]	$3.8B Net sales [1,2]	$3.8B Net sales [1,2]	$1.7B Net sales [1,2]
$1.5B Adjusted EBITDA [1]	$2.4B Adjusted EBITDA [1]	$1.9B Adjusted EBITDA [1]	$0.5B Adjusted EBITDA [1]
17,000 Number of employees [3]	3,200 Number of employees [3]	1,700 Number of employees [3]	1,500 Number of employees [3]

1 For the fiscal year ended December 31, 2023.
2 Related to manufactured products for Potash, Nitrogen and Phosphate.
3 As at December 31, 2023.

Nutrien has four reportable operating segments: Retail, Potash, Nitrogen and Phosphate. The Retail segment distributes crop nutrients, crop protection products, seed and merchandise, and provides services, including financing, directly to growers through a network of Retail selling locations in North America, South America and Australia. The Potash, Nitrogen and Phosphate segments are differentiated by the chemical nutrient contained in the products that each produces.

Operating segments

Nutrien has four reportable operating segments: Retail, Potash, Nitrogen and Phosphate. We are the world's premier retailer of crop inputs and services and operate the largest global network of fertilizer production and distribution assets.

R | Retail | #1 Global ag retailer

Our global Retail network of over 2,000 selling locations in seven countries provides growers with a comprehensive portfolio of value-added agronomic products and services that includes crop nutrients, crop protection products, seed and application services. The size and scale of our network provides reach and flexibility to reliably serve our customers throughout the growing season. We are focused on building leading digital capabilities that support data-driven insights to more efficiently serve our grower customers and offer competitive credit products that meet their crop input financing needs.

We produce an innovative portfolio of approximately 2,000 proprietary crop nutrient, crop protection and seed products. These proprietary products generate a higher margin for Nutrien and enhance crop production efficiency and profitability for the grower. We are a leading provider of plant nutritional products, including biostimulants, which aim to increase crop yields through enhanced nutrient efficiency and improved plant and soil health outcomes.

Over 4,000 crop consultants support our grower customers in crop planning, seed selection, soil sampling, variable rate fertilizer application and crop monitoring. Our agronomic tools and expertise combined with our broad portfolio of value-added products supports on-farm sustainability, enabling grower adoption of products and practices that maximize productivity and minimize environmental impacts.

K | Potash | #1 Global potash producer

We operate six low-cost potash mines in Saskatchewan, which have access to the best potash geology in the world and are located in a stable geopolitical environment, minimizing supply risk for our customers. We produce multiple grades of potash and our flexible network provides the ability to efficiently adjust operating capability in response to changing market conditions.

Our extensive North American transportation and distribution network includes approximately 5,900 owned or leased railcars serviced by multiple railway providers.

Through Canpotex – our joint venture potash export, sales and marketing company – we have access to four North American marine terminals and other facilities as needed to export potash to customers in approximately 40 countries around the world.

Our engagement practices help in building relationships and supporting our communities, including the procurement of materials and supplies from over 35 Indigenous owned and operated businesses.

N | Nitrogen | #3 Global nitrogen producer

We produce nitrogen at nine strategically located production facilities throughout Canada, the US and Trinidad and operate four regional product upgrade sites in North America. Our North American operations, which account for approximately 85 percent of our Nitrogen sales volumes, have access to some of the lowest cost natural gas in the world and are well positioned to serve agriculture and industrial markets. Our Trinidad operations support sales to approximately 30 countries and have natural gas supply contracts indexed to ammonia prices.

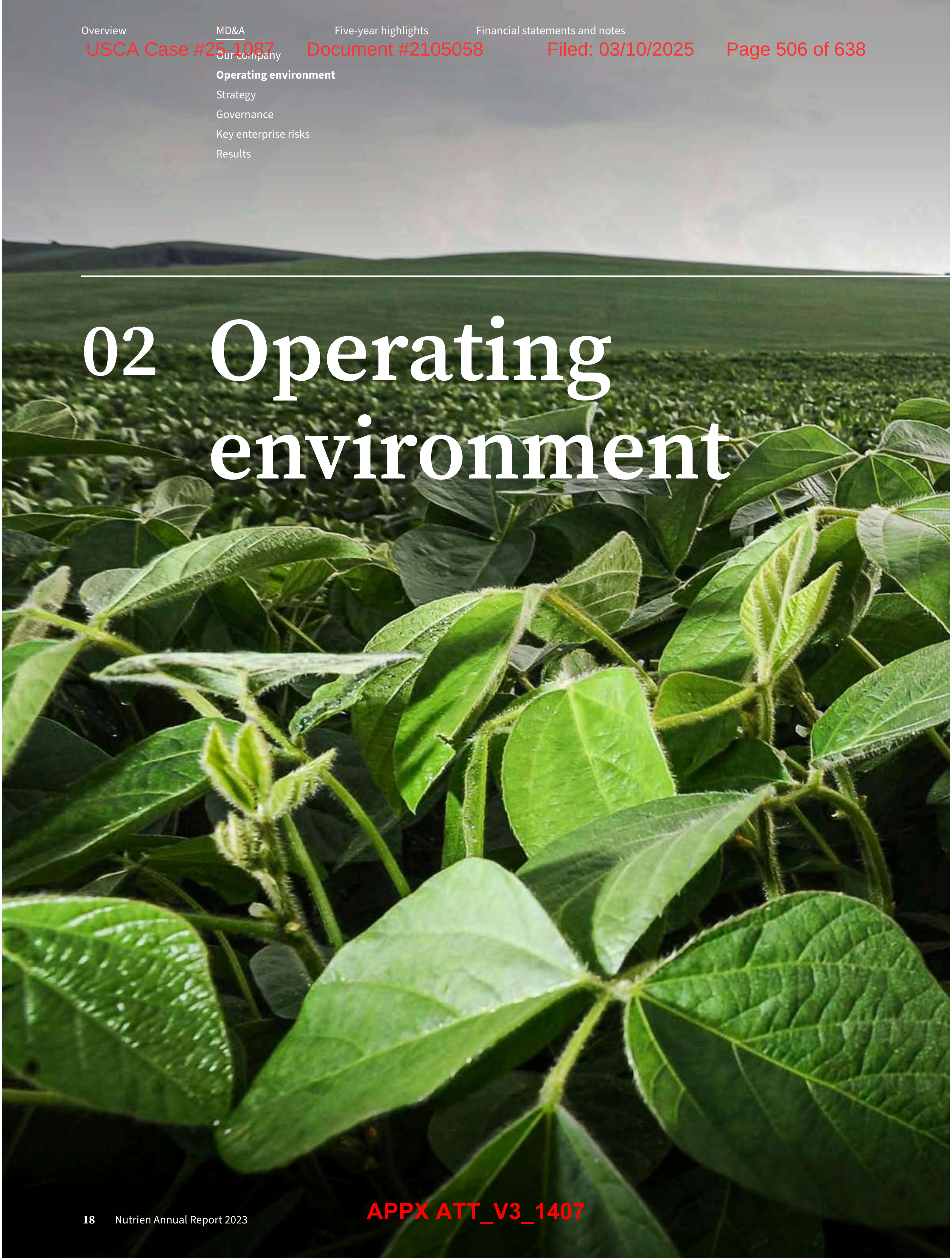
We produce a diverse portfolio of nitrogen products and have flexibility to optimize product mix in changing market conditions. Our transportation and distribution network leverages truck, rail, pipeline, barge and marine vessel modes, including direct access to tidewater in both the US and Trinidad.

We leverage CCUS at two of our facilities and have captured and sold at least 1 million tonnes of CO_2 annually for the last five years. We continue to support our grower customers to reduce their environmental impact by expanding our portfolio of manufactured products, including enhanced efficiency fertilizers such as ESN®.

P | Phosphate | #2 North American phosphate producer

Nutrien has two large integrated phosphate production facilities and four regional product upgrade sites in the US. Our high-quality phosphate rock enables production of a diverse mix of phosphate products, including solid and liquid fertilizers, feed and industrial acids. We are the largest producer of purified phosphoric acid in North America and sell the majority of our product in this market, benefiting from our extensive distribution network and customer relationships.

We have a strong focus on environmental stewardship, reclaiming thousands of acres of mined land every year to useful purposes, remediating soil and groundwater including the planting of over half a million trees in 2023, and reducing environmental risks through our commitment to sustaining our assets at the highest level.



02 Operating environment

Paraná, Brazil

Brazil is one of the largest and fastest growing agriculture markets in the world. The country produces over 150 million tonnes of soybeans annually, which requires a significant amount of potash. Brazil was the largest market for Canpotex potash sales in 2023.

Megatrends

We define megatrends as emerging macro-level trends and global dynamics that we believe will have ongoing impacts on business, government and society that are expected to shape our operating environment over the next decade. Tracking and analyzing megatrends informs Nutrien's strategy. See page 28 for more information on our related strategy and page 44 for our related key enterprise risks.

Food security

Despite advances in modern agriculture, food security remains a global challenge. Producing enough nutritious food for the world's eight billion people, and transporting it to where it is needed, is straining existing global resources. It is estimated that over 10 percent of the world's population is food insecure. A rising population, expected to grow by close to two billion people by 2050, is further increasing the scale of this challenge.

The agricultural landscape continues to evolve and be influenced by sustainability practices, climate change and social trends that could impact the ability to address global food security challenges. Nutrien is well positioned to develop innovative products and solutions to help our customers feed a growing population while addressing the environmental and social challenges the agriculture industry is facing.

Related enterprise risks:

- Agricultural changes and trends
- Climate change
- Stakeholder support

Climate change

Our business, industry, customers and other stakeholders in the agriculture value chain face long-term challenges related to climate change, including increasing expectations for climate actions and reductions of GHG emissions.

Physical risks from a changing climate can impact our operations, our customers and our supply chain. These include more intense weather events, longer droughts, rising sea levels, and changes in average temperature and precipitation patterns. Global decarbonization ambitions and the resulting energy transition are driving carbon regulations and informing capital allocation priorities of investors.

Nutrien faces evolving challenges related to potential regulatory changes, including carbon pricing. At the same time, a transition to a low-carbon economy could create significant opportunities for Nutrien to help growers manage these impacts and improve their resilience by facilitating the adoption of climate-smart agriculture practices and developing products that can improve yields in more challenging conditions. The energy transition is accelerating the development of technologies that can support our GHG emission reduction efforts.

Related enterprise risks:

- Climate change

Technology and digitalization

Digital technologies and access to vast amounts of data are supporting the transformation of our industry and Nutrien. In mining operations, advances in automation and autonomous mining are improving safety by removing workers from the more hazardous areas and enabling productivity increases. Agriculture and food systems are undergoing technological changes driven by big data, digital connectivity, artificial intelligence and innovations in biotechnology.

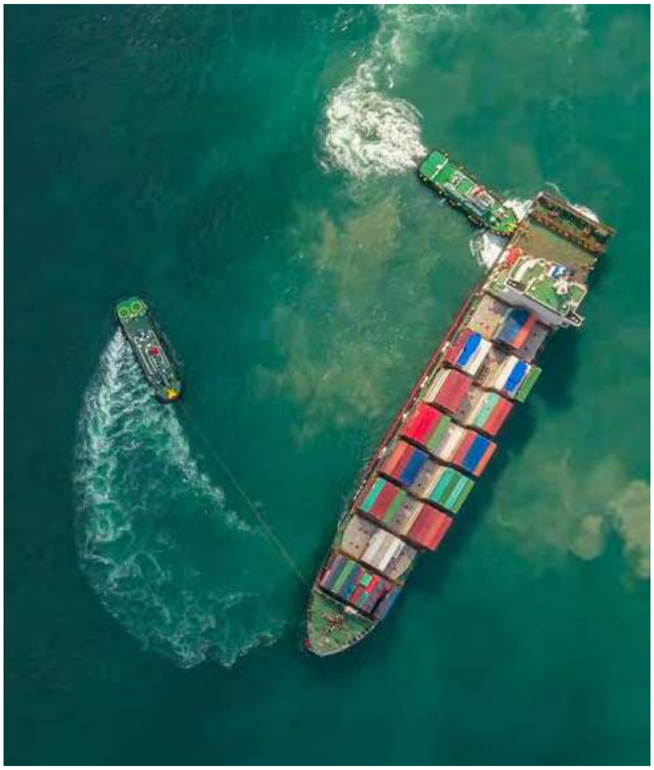
The regulatory environment around artificial intelligence continues to evolve across multiple jurisdictions. This evolution can cause uncertainty as to how these tools could be deployed and leveraged, how privacy and security safeguards will be incorporated, and levels of investment in innovation.

We also have an opportunity to help turn data into insights for our grower customers, and for our grower customers to turn those insights into actions, which presents further opportunities through the agriculture value chain.

The proliferation of technology and data also creates increased risks to our information systems and customer data. Our dependence on technology may contribute to cyber-related events becoming more disruptive and costly. As we gather increasingly more data from our customers, we are continually evolving our practices to align with data security and privacy regulations.

Related enterprise risks:

- Cybersecurity threats
- Agricultural changes and trends



Geopolitical volatility

Geopolitical turmoil around the world is being driven by nationalism, polarization and economic instability. Due to globalization, regional events are having global impacts. In particular, the continued war in Eastern Europe and the more recent escalation of tensions in the Middle East have resulted in, and may continue to result in, supply chain disruptions and price volatility for energy and several commodities.

Global geopolitical instability and resulting disruptions could impair our ability to distribute our products in a cost-effective and timely manner to our customers or disrupt our supply chains. If significant geopolitical events occur in one of the countries where we have significant operations, the impact could be more direct and affect our operations, production or revenues. Conversely, disruptions in markets could result in improvements to our financial performance through increased market share or higher sales.

Related enterprise risks:

- Political, economic and social instability

Societal expectations

Stakeholders are increasingly focused on corporate sustainability performance and disclosure. Investors are considering environmental and social principles alongside traditional financial metrics in capital allocation decisions and, along with regulators, are considering those principles in evaluating disclosure enhancements. In addition to climate-related matters, societal concerns include impacts on ecosystems and biodiversity, as well as challenges faced by underrepresented groups inside and outside of the workplace.

In response to these expectations, governments may impose new regulations or increase the stringency of existing ones. If we are not able to meet stakeholder expectations for environmental and social performance and disclosure, it could be more difficult to access cost-efficient capital, retain talent or maintain our freedom to operate.

Nutrien believes that our response to these trends will not only help to address some of the world's most pressing challenges but also create opportunities to differentiate ourselves from our competitors. Delivering on our sustainability commitments can attract new investors, support internal engagement, and help attract and retain talent.

Related enterprise risks:

- Changing regulations
- Stakeholder support
- Talent and organization culture

Market fundamentals and outlook

We carefully monitor market fundamentals and our competitive landscape in order to anticipate and adapt to the environment in which we operate. Understanding our operating environment and expectations for the future positions us to better identify and manage risks that could jeopardize our ability to deliver on our strategy and capitalize on emerging opportunities.

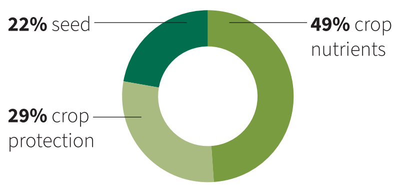
R | Retail

$130B

2023 total market crop input sales [1]

Crop input sales by product (2023) [1]

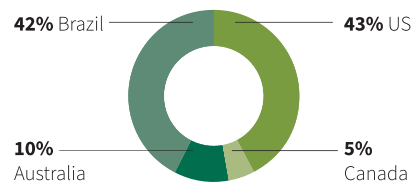
(percent)



Source: USDA, StatsCan, ABARES, Conab, IMEA, AgbioInvestor, Nutrien

Crop input sales by region (2023) [1]

(percent)



Source: USDA, StatsCan, ABARES, Conab, IMEA, AgbioInvestor, Nutrien

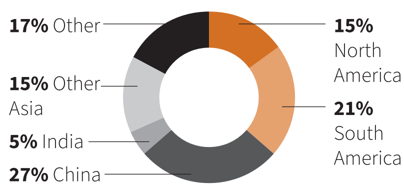
K | Potash

67-68Mmt

2023 global potash (KCl) demand

Global potash demand (2023)

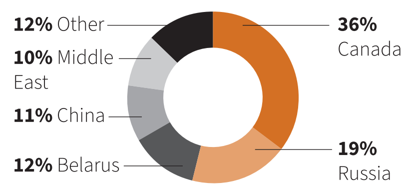
(percent)



Source: CRU

Global potash production (2023)

(percent)



Source: CRU

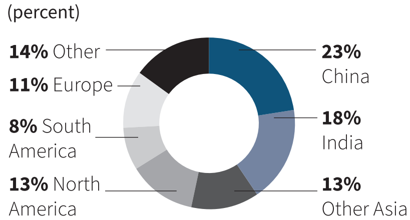
N | Nitrogen

~155Mmt

2023 global nitrogen (N) demand

Global nitrogen demand (2023)

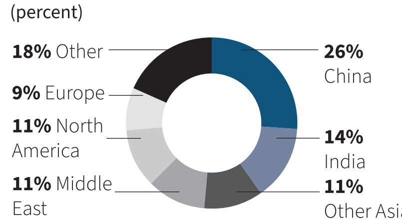
(percent)



Source: SPGCI

Global nitrogen production (2023)

(percent)



Source: SPGCI

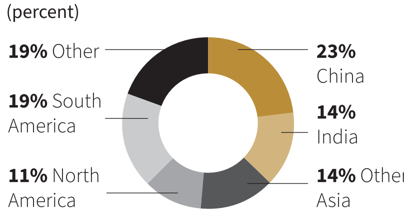
P | Phosphate

~51Mmt

2023 global phosphate (P_2O_5) demand

Global phosphate demand (2023)

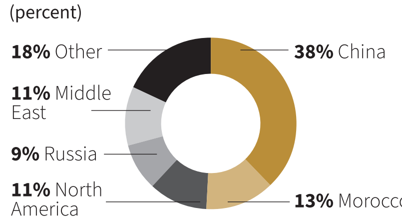
(percent)



Source: CRU

Global phosphate production (2023)

(percent)



Source: CRU

1 Represents total market sales of seed, fertilizer and crop protection products in the US, Canada, Australia and Brazil.

R | Retail

Market fundamentals
Total crop protection, seed and fertilizer sales in our major Retail operating regions equated to approximately $130 billion in 2023. As the need to feed the world's population increases, growers are challenged to sustainably increase yields from a finite arable land base. This drives growth in demand for crop inputs and agronomic services.

The agriculture retail industry is highly fragmented in most of the major markets in which we operate, primarily composed of small and medium-sized competitors. Scale, reliability of supply and the ability to provide innovative products and solutions, including digital offerings that support sustainable agriculture, are increasingly important to growers.

In North America, the largest crops grown include canola, corn, cotton, soybean and wheat. It is a more mature market with growers leveraging advanced agriculture tools and who are willing and able to invest in high- value products and services.

In Australia, growers require a full suite of crop production inputs but also solutions for livestock, water and irrigation services.

Brazil is one of the world's largest and fastest growing agriculture markets. It is currently the largest soybean producer and the third largest producer of corn globally. Its retail industry is highly fragmented, and there remains opportunity for investment and adoption of more advanced products and services at the grower level.

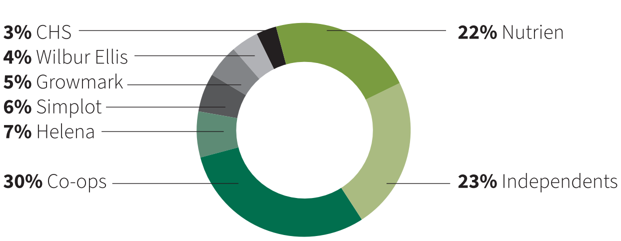
Market outlook
Global grain stocks-to-use ratios remain historically low going into the 2024 growing season as tightening supplies of wheat and rice have offset increased corn supplies in the US and Brazil. We expect weather and geopolitical issues will continue to impact grain and oilseed production, exports and inventory levels.

Crop prices have declined from historically high levels in 2022, but lower crop input prices have resulted in improved demand, evidenced by the strong North American fall application season in 2023. We expect US corn plantings to range from 91 to 92 million acres in 2024 and soybean plantings to range from 87 to 88 million acres.

In Brazil, dry weather during the summer crop growing season and lower corn prices could result in lower corn area in 2024. Brazilian growers are expected to continue to expand soybean acreage, which we anticipate will support the need for strong fertilizer imports in the second and third quarters of 2024.

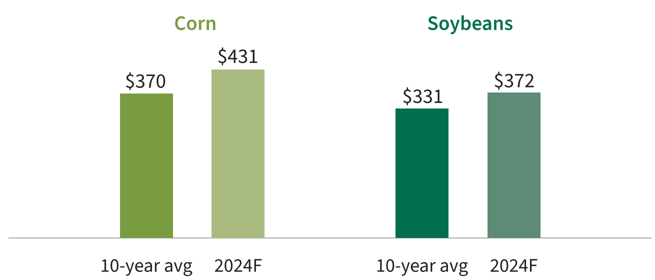
In Australia, growers have benefited from multiple years of above-average yields and fundamentals remain supportive entering 2024. Timely precipitation led to higher-than-expected winter crop production, however if the El Niño weather pattern continues, it could pose a risk for the 2024 growing season.

US ag retail industry profile (2023)
(percent)



Source: Croplife

US grower cash production margins [1]
(US$ margin per acre)



Source: CRU, Fertecon, USDA, Bloomberg, Nutrien

1 Forecasts use the December 2024 corn and November 2024 soybean futures contracts as of January 30, 2024.

K | Potash

Market fundamentals
Potash strengthens root systems including water uptake, drought and disease tolerance and increases the uptake of other nutrients – all important in volatile growing conditions. Potash demand growth is driven by increasing nutrient requirements of higher-yielding crops and improving soil fertility practices, particularly in emerging markets where potash has been historically under-applied and crop yields lag.

High-quality potash reserves in significant quantities are limited to a small number of countries. Canada has the largest known global potash reserves, accounting for approximately 40 percent of the total. More than 75 percent of the world's potash capacity is held by the six largest producers.

Building new production capacity requires significant capital and time to bring online. Brownfield projects have a significant per-tonne capital cost advantage over greenfield projects.

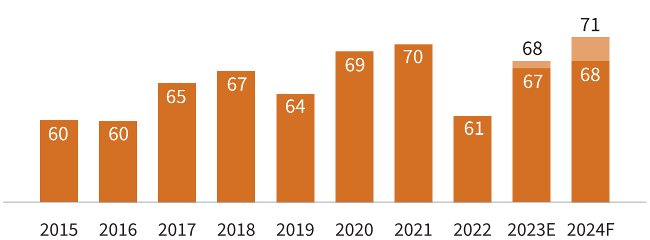
Most major potash-consuming countries in Asia and Latin America have limited or no production capability and rely on imports to meet their needs. Trade typically accounts for approximately three-quarters of demand for potash, resulting in a globally diversified marketplace.

Market outlook
Global potash demand was strong through the second half of 2023, and we estimate full-year shipments were between 67 to 68 million tonnes. The increase was supported by strong consumption and increased imports in key markets such as North America, China and Brazil.

We expect global potash demand will continue to recover towards trend levels in 2024 with full-year shipments projected between 68-71 million tonnes. We anticipate a relatively balanced global market with incremental supply from producers in Canada, Russia, Belarus and Laos.

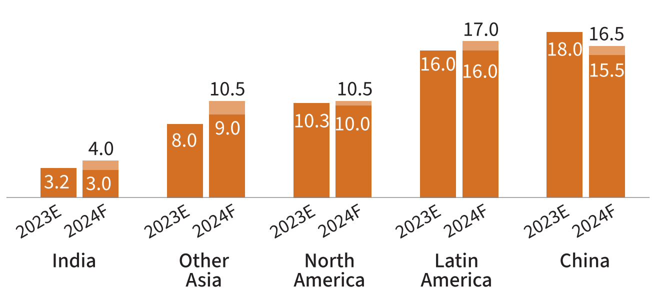
We are seeing strong potash demand ahead of the North American spring application season as channel inventories were tight to start the year. Potash demand in Southeast Asia is expected to increase significantly in 2024 due to much lower inventory levels compared to the prior year and favorable economics for key crops such as oil palm and rice. We expect lower potash imports from China compared to the record levels in 2023 but for demand to remain at historically high levels driven by increased consumption.

Global potash demand
(millions of tonnes KCl)



Source: IFA, Argus, CRU, Nutrien

Potash demand in key regions
(millions of tonnes KCl)



Source: Industry Consultants, Nutrien

N | Nitrogen

Market fundamentals
Nitrogen is an essential crop nutrient and is a fundamental building block of plant proteins that improve both crop yield and quality. The necessity of nitrogen for crop yield supports a strong and growing demand source for nitrogen fertilizers. Additionally, nitrogen is used as an input in many industrial processes and has the potential to provide further value as markets for low-carbon ammonia emerge.

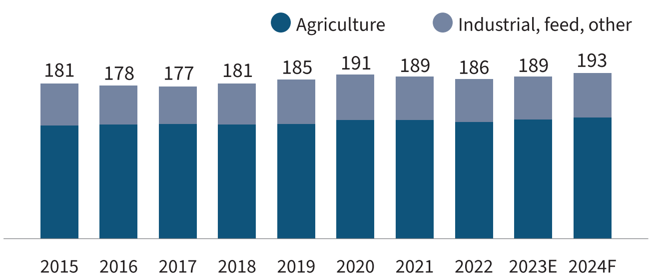
Production of nitrogen products is the most geographically diverse of the three primary crop nutrients due to the widespread availability of hydrogen sources. Access to reliable and competitively priced energy feedstock supply is an important driver of profitability, as recent geopolitical events have created additional volatility in certain global energy markets. North American nitrogen producers currently have an advantaged cost position due to the relatively low price of natural gas compared to competitors in Europe and Asia.

The US remains one of the largest importers of nitrogen products and a key driver of global trade despite a significant increase in domestic capacity and production over the past decade. China and India are the largest-consuming countries of nitrogen products, accounting for approximately 40 percent of the world's consumption.

Market outlook
We expect nitrogen supply constraints to persist in 2024, including limited Russian ammonia exports, reduced European operating rates and Chinese urea export restrictions. North American natural gas prices remain highly competitive compared to Europe and Asia, and we expect Henry Hub natural gas prices to average approximately $2.50 per MMBtu for the year.

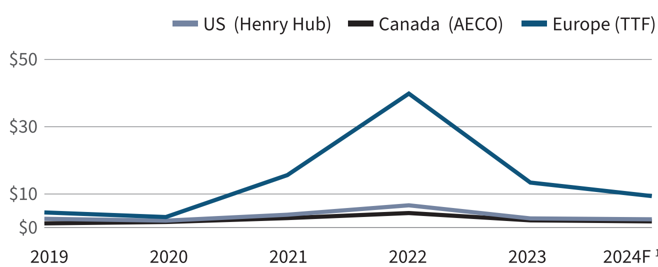
The US nitrogen supply and demand balance is projected to be tight ahead of the spring application season, as nitrogen fertilizer net imports in the first half of the 2023/2024 fertilizer year were down an estimated 55 percent compared to the three-year average. Global industrial nitrogen demand remains a risk in 2024 as industrial production, most notably in Europe and Asia, has yet to rebound to historical levels.

Global ammonia demand
(millions of tonnes)



Source: SPGCI

Natural gas prices in key regions
(US$ per MMBtu)



Source: ICE, CME, Nutrien

1 Futures prices as of February 7, 2024. AECO based on US Henry Hub forecast less $1.00/MMBtu of basis.

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P | Phosphate

Market fundamentals
Phosphorus is essential to all living things and is key to energy reactions in the plant, particularly photosynthesis, and vital to plant growth. Demand for phosphate fertilizers has steadily increased over the last 20 years. Additionally, phosphate is used as an input in many feed and industrial processes.

Phosphate rock is found in significant quantity and quality in only a handful of geographic locations. Given the concentration of deposits in North Africa and the Middle East, government involvement is a major consideration when evaluating potential phosphate project developments.

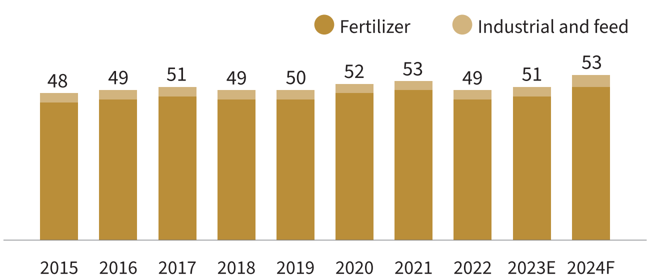
The majority of new phosphate fertilizer supply over the past decade was from producers in China, Morocco, Russia and Saudi Arabia. As a result, total US phosphate production declined by approximately 30 percent over this period.

China's trade policy has a major impact on the global phosphate market. In 2023, Chinese DAP/MAP exports were down approximately 30 percent from 2021 levels as a result of export restrictions.

India and Brazil are the largest importers of phosphate fertilizers, with limited domestic production. In more mature markets like North America, we have seen continued demand growth for phosphate fertilizers that incorporate secondary nutrients and micronutrients like Nutrien's MAP+MST product.

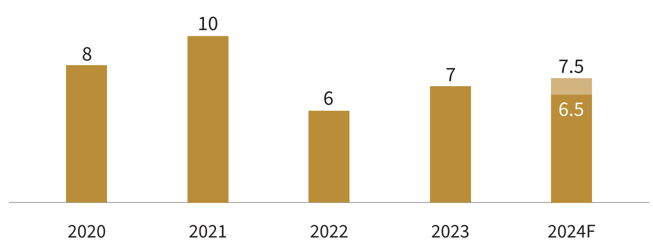
Market outlook
Phosphate fertilizer markets have remained relatively strong in the first quarter of 2024, particularly in North America where channel inventories were low entering the year. We expect Chinese phosphate export restrictions to be similar to 2023 levels and tight stocks in India to support demand ahead of their key planting season.

Global P_2O_5 demand
(millions of tonnes)



Source: CRU

China DAP/MAP exports
(millions of tonnes)



Source: CRU, Argus, Nutrien

03 Strategy

Victoria, Australia

Canola is Australia's major oilseed crop. Grown in Australia's Grain Belt, canola production has increased significantly to an average of 3 million tonnes per year. Nutrien has 385 Retail selling locations in Australia to support growers of many different crops, including canola.

Nutrien's strategy

Our vision is to be the leading global integrated agriculture solutions provider, delivering superior shareholder value through sustainable operations. In pursuit of our vision, we utilize our integrated business to optimize enterprise value by enhancing our core business, allocating capital to high-value strategic investments and progressing initiatives that fortify our business for the future.

Enhance our core business

Increase operational efficiency and asset utilization, maximize cost savings, and focus on integration and investments that enhance margins and free cash flow.

Advance high-value strategic initiatives

Allocate capital to high-value and high-conviction investments that generate significant long-term returns for our shareholders.

Fortify our business for the future

Focus on initiatives that reduce GHG emissions, enhance on-farm environmental performance, invest in our people and procurement programs, and position our Company to sustainably deliver on our current and future business needs.

R | Retail strategic priorities

We are advancing our global Retail network through a combination of organic growth, accretive acquisitions, and optimization initiatives that expand our ability to provide whole-acre solutions for growers and enables us to be the leading customer-first ag solutions provider.

Business optimization

Enhance our core business

Achieve best-in-class commercial execution, rationalize costs and maximize network efficiencies and integration synergies

Key 2023 activities

- Centralized and modernized five locations in our core markets, allowing us to serve the customer more safely and efficiently
- Paused our expansions and acquisitions in Brazil, focusing on integrating recently acquired businesses
- Optimized our North American footprint through the closure and consolidation of 10 locations

Digital innovation

Enhance our core business

Prioritize digital capability development that supports our core business offering, improves decision-making, drives efficiency and enhances our grower value proposition

Key 2023 activities

- Launched a digitally enabled financing platform in Australia, enhancing our grower value proposition
- Empowered our grower customer financial operations with new digital decision-making tools through advancements to our digital innovation in North America

Targeted expansion and proprietary products

Advance high-value strategic initiatives

Grow earnings and share in core geographies through targeted network expansion and investment in high growth categories, such as biological product technologies

Key 2023 activities

- Contributed $1.0 billion in gross margin from our global proprietary products portfolio, with growth of 6 percent per year over the last five years
- Continued to extract value from our innovation pipeline, realizing over $750 million in global proprietary plant nutrition and biostimulant sales in 2023
- Completed 23 acquisitions in our core Retail markets

Sustainability outcomes

Fortify our business for the future

Development of scalable sustainability programming, featuring solutions that improve grower productivity and efficiency and generate value for Nutrien and our diverse group of partners

Key 2023 activities

- Doubled our sustainably engaged acres to two million, continuing integration of our high-value products and services into our outcome-based sustainability programming
- Generated first verified GHG offsets and insets from our sustainability programming, creating opportunities for deeper value-chain collaboration and partner connectivity

K | Potash strategic priorities

We are utilizing our world-class Potash network and integrated supply chain to respond to market supply and demand dynamics. We continue to invest in efficiency and new technologies to manage our costs, optimize and modernize our asset base, advance our sustainability commitments, and preserve the reliability and safety of our operations.

Operational excellence

Enhance our core business

Deliver initiatives that improve safety, reduce costs, increase network flexibility and improve our environmental footprint

Key 2023 activities

- Increased annual ore tonnes cut using autonomous mining by 40 percent and continue to scale these technologies across our network
- Completed ore recovery projects alongside other efficiency related initiatives to maintain an advantaged global cost position and reduce waste

Supply chain optimization

Enhance our core business

Pursue opportunities that promote growth and strengthen the channel to our customers

Key 2023 activities

- Enhanced value of our integrated business by sourcing a significant majority of Retail's North American supply needs from our six potash mines in Saskatchewan

Leverage flexibility and optimize value

Advance high-value strategic initiatives

Ensure a flexible go-to-market strategy that responds to variable conditions, satisfies demand requirements and optimizes long-term value as the market grows

Key 2023 activities

- Paused the accelerated ramp-up of our annual potash production capability to 18 million tonnes in response to market conditions and continued to advance certain in-flight projects to maximize value of capital spent and support long-term growth

Strengthen our workforce

Fortify our business for the future

Action our workforce strategy to deliver talent and skills for tomorrow and support our future needs

Key 2023 activities

- Executed attraction and retention initiatives that strengthen our workforce and support diversity and inclusion, including local and Indigenous partnerships

N | Nitrogen strategic priorities

We are enhancing our strategically positioned Nitrogen business through investment projects that improve the reliability and energy efficiency of our facilities while selectively increasing capacity and product mix flexibility. We are unwavering in our pursuit of safe, reliable and efficient operations while continuing to leverage process and product innovations to proactively address sustainability needs.

Operational excellence

Enhance our core business

Maintain globally competitive position, increasing product mix flexibility and improving reliability, efficiency and supply chain performance

Key 2023 activities

- Completed major maintenance turnarounds at our Geismar and Borger sites, addressing reliability needs and increasing efficiency
- Completed initial construction and technology development of our Nitrogen Real-time Operations Center, providing troubleshooting, monitoring and optimization support across our entire network of 13 nitrogen production and upgrade facilities

Invest in our North American assets

Advance high-value strategic initiatives

Selectively invest in high-conviction, high-return growth opportunities in North America, supporting the needs of the market

Key 2023 activities

- Expanded our Geismar facility, adding incremental ammonia and nitric acid production capacity
- Completed UAN debottleneck projects at our Geismar site, allowing for the expansion of production as additional nitric acid capacity projects planned for 2024 are completed
- Suspended work on our Geismar clean ammonia plant as we monitor cost estimates and the evolving market for clean ammonia

Sustainability outcomes

Fortify our business for the future

Maintain position as an industry leader in low-carbon nitrogen production and continue to leverage process and product innovations to proactively address sustainability needs

Key 2023 activities

- Completed our GHG Phase 1 abatement program, including the CO_2 tie-in at our Redwater plant and an N_2O abatement project at Geismar
- Increased our low-carbon ammonia production capability to 1.2 million tonnes across our Geismar, Redwater and Joffre sites

P | Phosphate strategic priorities

We are optimizing our phosphate business by continuing to focus on safety, sustainability and operating efficiencies, while leveraging our product mix and adapting to market conditions.

Operational excellence

$ | Enhance our core business

Increase base business efficiency through reliability and efficiency improvements

Key 2023 activities

- Completed maintenance turnarounds at both Aurora and White Springs sites focused on key reliability improvements
- Achieved a 3 percent improvement to our preventative maintenance compliance metric, a key leading reliability indicator

Premium products and mix flexibility

$ | Enhance our core business

Maximize value via flexibility of product portfolio mix and focus on liquid fertilizer, feed, purified, and other premium product opportunities in North America

Key 2023 activities

- Fulfilled 56 percent of sales volumes attributable to higher-margin products, including liquid fertilizer, feed and purified
- Increased sales of our micronized sulfur dry phosphate product, MAP+MST by 125 percent compared to 2022 levels

Reclamation and environmental risk reduction

Fortify our business for the future

Continue to advance reclamation efforts and proactively address environmental risks

Key 2023 activities

- Planted over 500,000 trees and continued our land reclamation efforts at our Aurora and White Springs sites

Capital allocation

Our capital allocation framework prioritizes sustaining safe and reliable operations, a healthy balance sheet, strategically investing in our business, and providing meaningful returns to our shareholders through a stable and growing dividend and share repurchases. This balanced approach supports our strategy and enables us to enhance our core business, advance high-value strategic initiatives and fortify our business for the future.

Safe and reliable operations	• Sustain our assets to support safe and reliable operations • Focus on continuous improvement initiatives and investments that enhance the utilization rates, reliability and efficiency of our assets
Strong balance sheet	• Provide sufficient and flexible access to liquidity while optimizing the cost of our capital through the cycle • Expect to maintain adjusted net debt/adjusted EBITDA leverage ratio below three times, through the cycle
Shareholder returns	• Return capital to shareholders through a combination of stable and growing dividends and share repurchases • Factor reduction in share count in the decision criteria for future dividend per share growth
High-value growth opportunities	• Selectively invest in high-value and high-conviction opportunities that are expected to generate significant long-term returns • Evaluate investment opportunities by strategic fit, project economics using various financial return metrics and sustainability factors to align with our 2030 commitments and targets

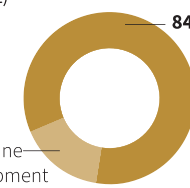
Capital allocation

Safe and reliable operations

Sustaining, mine development and pre-stripping capital expenditures [1]

$1.7B
2023

Sustaining, mine development and pre-stripping capital expenditures (2023)
(percent)

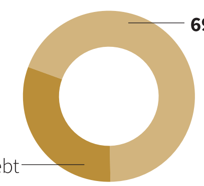


Strong balance sheet

Adjusted Net Debt/ Adjusted EBITDA [2]

1.9x
2023

Debt and equity [4,5] **(2023)**
(percent)

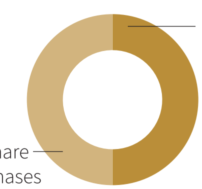


Shareholder returns

Cash used for dividends and share repurchases [1]

$2.1B
2023

Cash used for dividends and share repurchases (2023)
(percent)



High-value growth opportunities

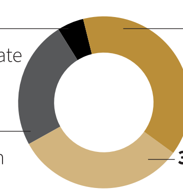
Investing capital expenditures [1]

$1.0B
2023

Business acquisitions [3]

$0.2B
2023

Investing capital expenditures [1] **(2023)**
(percent)



1 These are supplementary financial measures. See the "Other Financial Measures" section.
2 This is a capital management financial measure that includes a non-GAAP component. See the "Non-GAAP Financial Measures" and "Other Financial Measures" sections.
3 Net of cash acquired.
4 As at December 31, 2023.
5 Debt includes short-term debt, long-term debt and lease liabilities, including the current portions of each where applicable.

Key 2023 actions

- Completed reliability work and replaced key identified end-of-life assets across our operations, including major maintenance turnarounds and planned outages at five of our Nitrogen sites
- Invested in maintenance and safety-related initiatives for our Retail facilities

Key 2023 actions

- Maintained our BBB investment-grade credit rating
- Repaid $500 million in senior notes that matured during the year and issued a total of $1.5 billion of 5-year and 30-year senior notes
- Reduced planned capital expenditures by $300 million providing flexibility on capital allocation alternatives

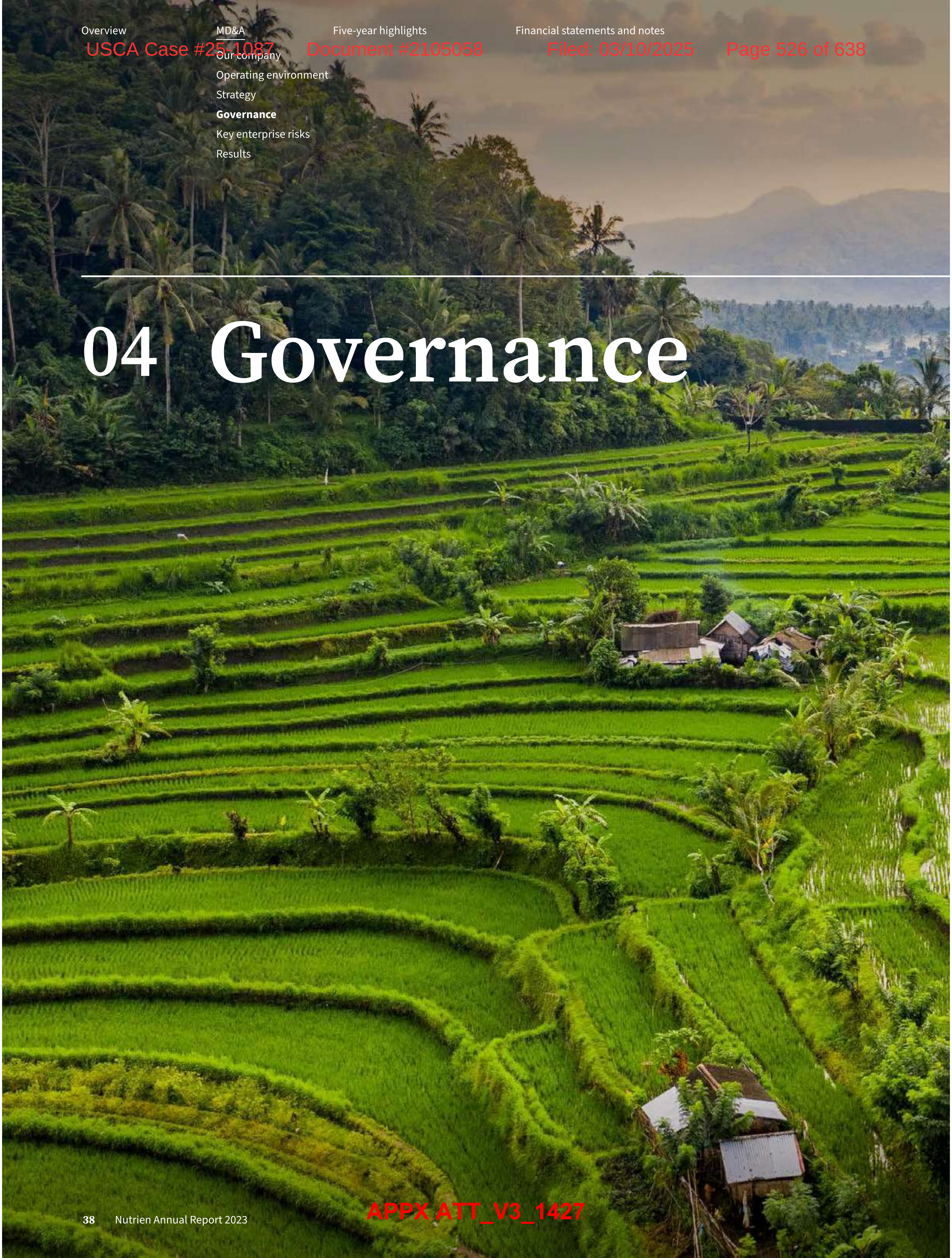
Key 2023 actions

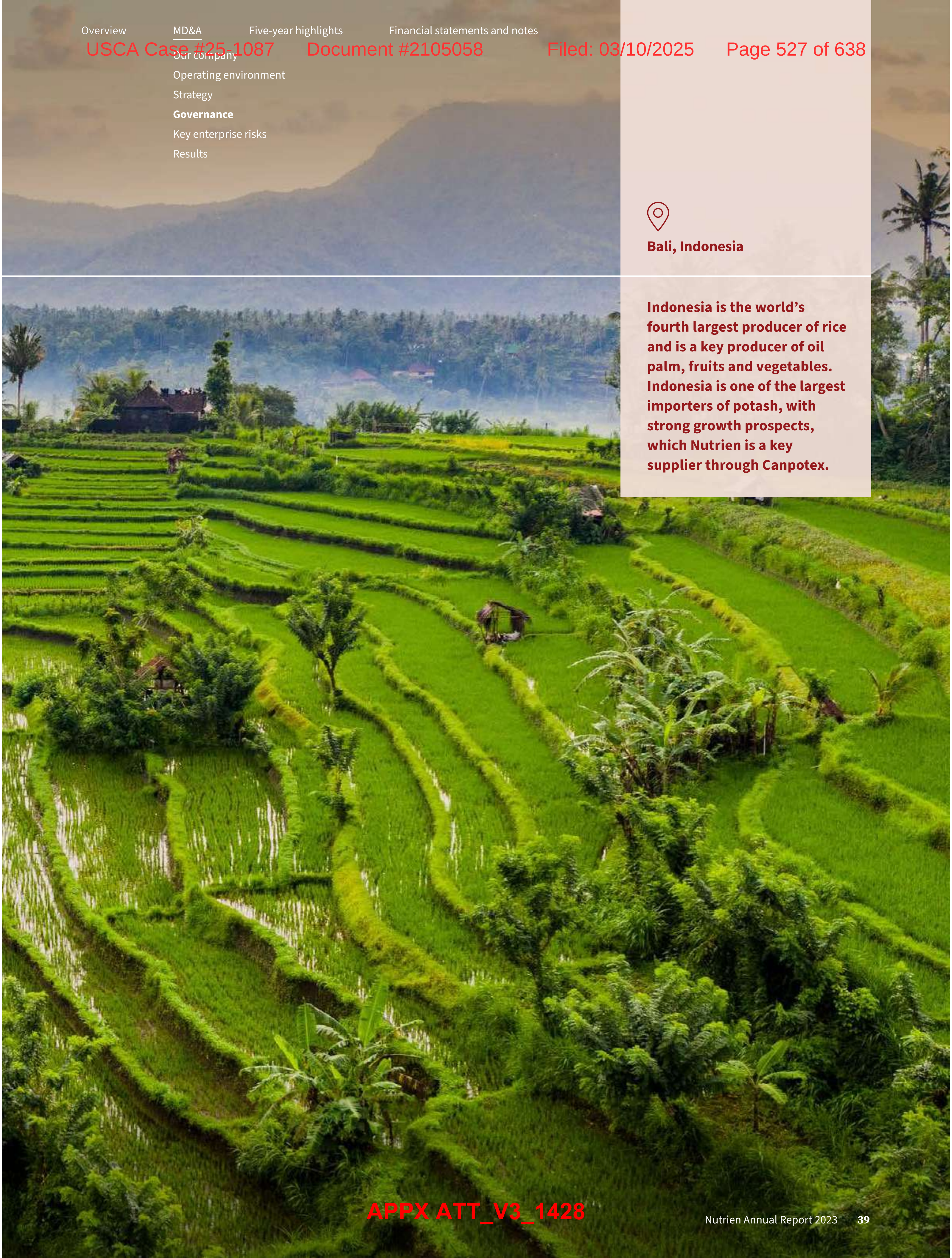
- Returned a total of $2.1 billion to shareholders through dividends and share repurchases
- Dividend provided an average yield of 3.3 percent in 2023
- In February 2024, we announced a 2 percent increase to our quarterly dividend to $0.54 per share, our sixth increase since 2018

Key 2023 actions

- Completed 23 Retail acquisitions across the US, Australia and Brazil
- Invested in our Potash network including the procurement of additional autonomous mining machines and technology
- Completed Nitrogen brownfield expansion projects at our Geismar facility, increasing ammonia and nitric acid capability
- Invested in digital, proprietary products and sustainability related strategies to grow the business and reduce our environmental impact

04 Governance





Bali, Indonesia

Indonesia is the world's fourth largest producer of rice and is a key producer of oil palm, fruits and vegetables. Indonesia is one of the largest importers of potash, with strong growth prospects, which Nutrien is a key supplier through Canpotex.

Corporate governance

Nutrien's Corporate Governance Structure includes policies and processes that define the roles of the Board and the Executive Leadership Team ("ELT"). Our Board oversees risk management and the execution of our corporate strategy. Below are highlights of our corporate governance practices. For more information, see our most recent Management Information Circular.

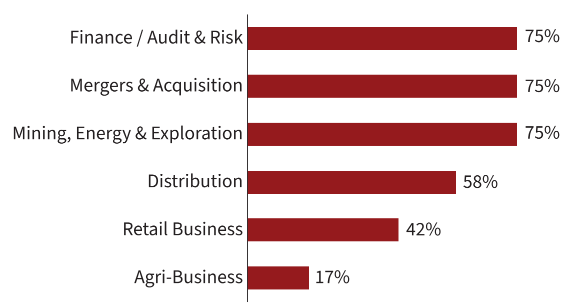
Board diversity
Having a mix of directors on the Board from varied backgrounds and with a diverse range of experience and skills fosters enhanced decision-making capacity and promotes strong corporate governance. Our Board Diversity Policy includes a target that women comprise no fewer than 30 percent of the Board members. As of December 31, 2023, four of our directors were women (33 percent of the total number of directors).

Executive compensation
Nutrien's compensation framework is based on a pay-for-performance philosophy, with the majority of executive compensation being at risk. Since 2020, a component of executive compensation has been tied to demonstrated sustainability performance, including the addition of progress on GHG emission reduction projects and diversity-related metrics in 2021. Each year, we include an advisory "say on pay" vote at our annual meeting (in line with 2019 amendments in the Government of Canada's Bill C-97).

Board skills
Our Board competencies and skills matrices are essential tools to evaluate whether the Board has the right skills, perspectives, experience and expertise for proper oversight and effective decision making. The Board regularly reviews the skills matrix.

Core business skills [1]
(percent of Board of Directors)

Core industry experience [1]
(percent of Board of Directors)



1 As disclosed in Nutrien's 2023 Management Proxy Circular.

Board of Directors

Russell Girling
Chair

Ken Seitz
President and Chief Executive Officer

Christopher Burley
Director

Maura Clark
Director

Michael Hennigan
Director

Miranda Hubbs
Director

Raj Kushwaha
Director

Alice Laberge
Director

Consuelo Madere
Director

Keith Martell
Director

Aaron Regent
Director

Nelson Luiz Costa Silva
Director

Executive Leadership Team

Ken Seitz
President and Chief Executive Officer

Noralee Bradley
Executive Vice President, External Affairs and Chief Sustainability and Legal Officer

Pedro Farah
Executive Vice President and Chief Financial Officer

Andrew Kelemen
Executive Vice President, Corporate Development and Chief Strategy Officer

Chris Reynolds
Executive Vice President and President, Potash

Jeff Tarsi
Executive Vice President and President, Global Retail

Mark Thompson
Executive Vice President, Chief Commercial Officer

Trevor Williams
Executive Vice President and President, Nitrogen and Phosphate

Risk governance

Risk management is an integral part of doing business and is governed by our Board, which has the highest level of oversight for risk governance. The Board is responsible for overseeing the execution and alignment of Nutrien's corporate strategy and risk management processes.

Nutrien's ELT has the responsibility of ensuring the Company's principal risks are being appropriately identified, assessed and addressed. Management keeps the Board and each of the Board committees regularly apprised of risks and developments relevant to their mandates.

Responsibility and accountability for risk management are embedded in all levels of our organization, and we strive to integrate risk management into key decision-making processes and strategies. By considering risk throughout our business, we seek to effectively manage the risks that could have an impact on our ability to deliver on our strategy.

Role of the Board committees
While the Board as a whole oversees our strategy and risk management processes, each Board committee has oversight over business topics and certain risk areas relevant to their committee mandate. More information can be found in Nutrien's Board and Board committee charters on our website at **nutrien.com**.

Board/Board Committee	Oversight includes the following business topics or risk areas	
Board of Directors	• Corporate strategy • Oversight of safety, health, environmental and security matters	• Risk management • Human resources and compensation • Governance and compliance
Audit Committee	• Accounting and financial reporting • Internal controls	• Compliance • Financial risk management
Corporate Governance & Nominating Committee	• Corporate governance • Board diversity	• Director orientation and continuing education • Board evaluation
Human Resources & Compensation Committee	• Executive compensation • Succession planning	• Equity, diversity and inclusion, including the Company's Indigenous Strategy as it relates to Indigenous employment and human resources matters with appropriate coordination with the S&S Committee • Learning and development
Safety & Sustainability ("S&S") Committee	• Sustainability targets and goals • Risks, strengths and opportunities related to safety and sustainability including climate-related impacts	• Safety and sustainability performance and strategy • Cybersecurity and data privacy • Status of remediation projects and environmental provisions • The Company's Indigenous Strategy as it relates to Indigenous engagement and stakeholder relations, with appropriate coordination with the Human Resources & Compensation Committee

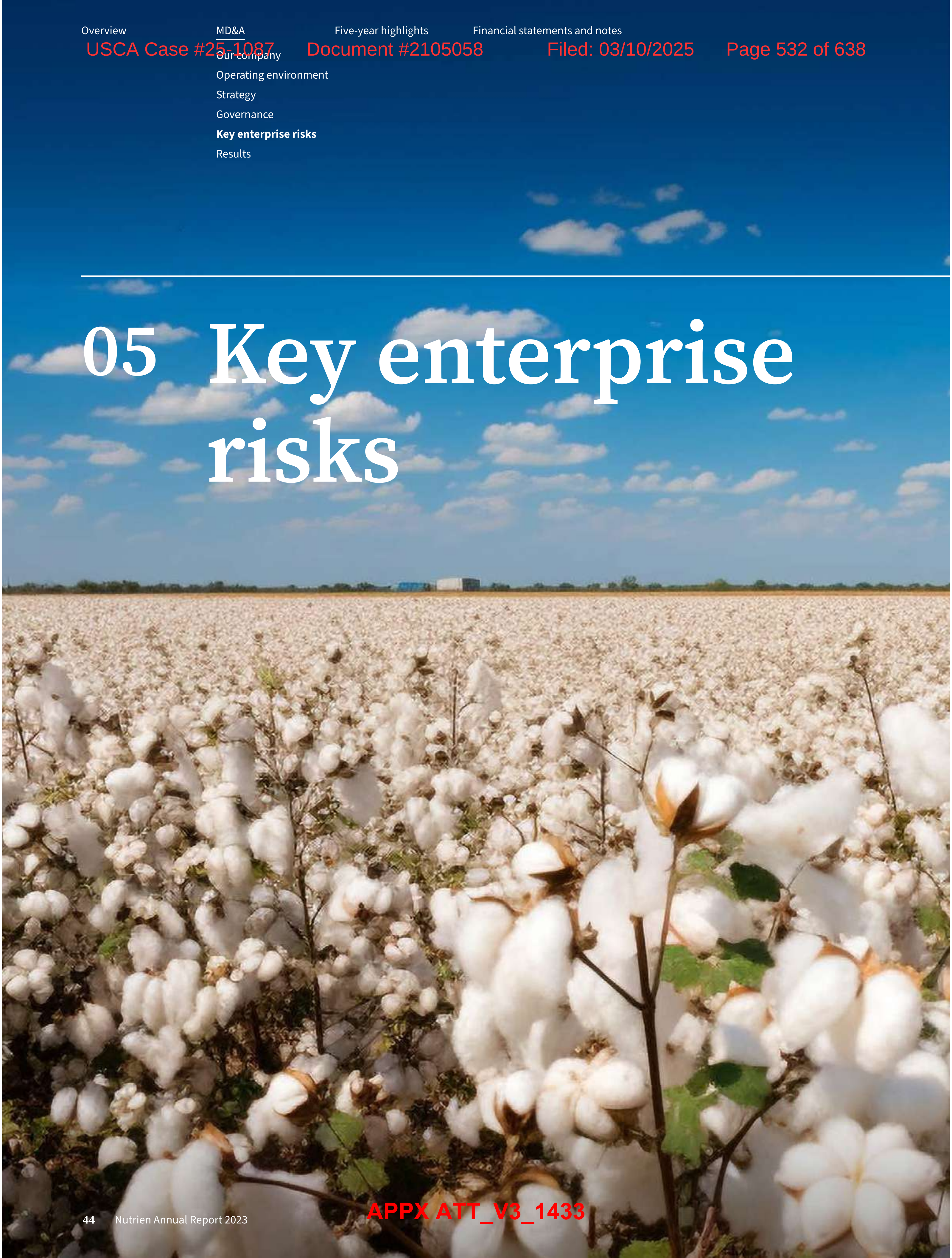
Governance for climate and sustainability
The Board's S&S Committee has oversight over Nutrien's climate-related risks and opportunities. The S&S Committee generally meets on a quarterly basis and covers many sustainability related matters within its mandate including those related to climate. Specifically, the S&S Committee's role includes overseeing: policies relating to sustainability and progress towards sustainability goals; approval of Nutrien's annual Global Sustainability Report; reviewing progress against Nutrien's Feeding the Future Plan and associated sustainability targets and goals; and review of Nutrien's climate-related risks and opportunities. This committee directly advises the Board on these and other sustainability matters noted above.

Risk management process

Risk management is integrated into our strategy and business activities to facilitate informed decision making and responsible management of resources. Our Enterprise Risk Management process is overseen by our Enterprise Risk Management Team and guided by our global risk management framework. The framework promotes consistent and integrated application of risk management principles and processes across our organization and is scalable to support all levels of the business.

Nutrien's operating segments and corporate functions use this framework to identify, assess and develop mitigation actions for key risks that could affect their strategy, operations or future performance. Assessment criteria embedded in the risk framework allow for comparability of different types of risks, including climate-related risks. Key criteria include the likelihood of impacting our business and the potential severity of impact.

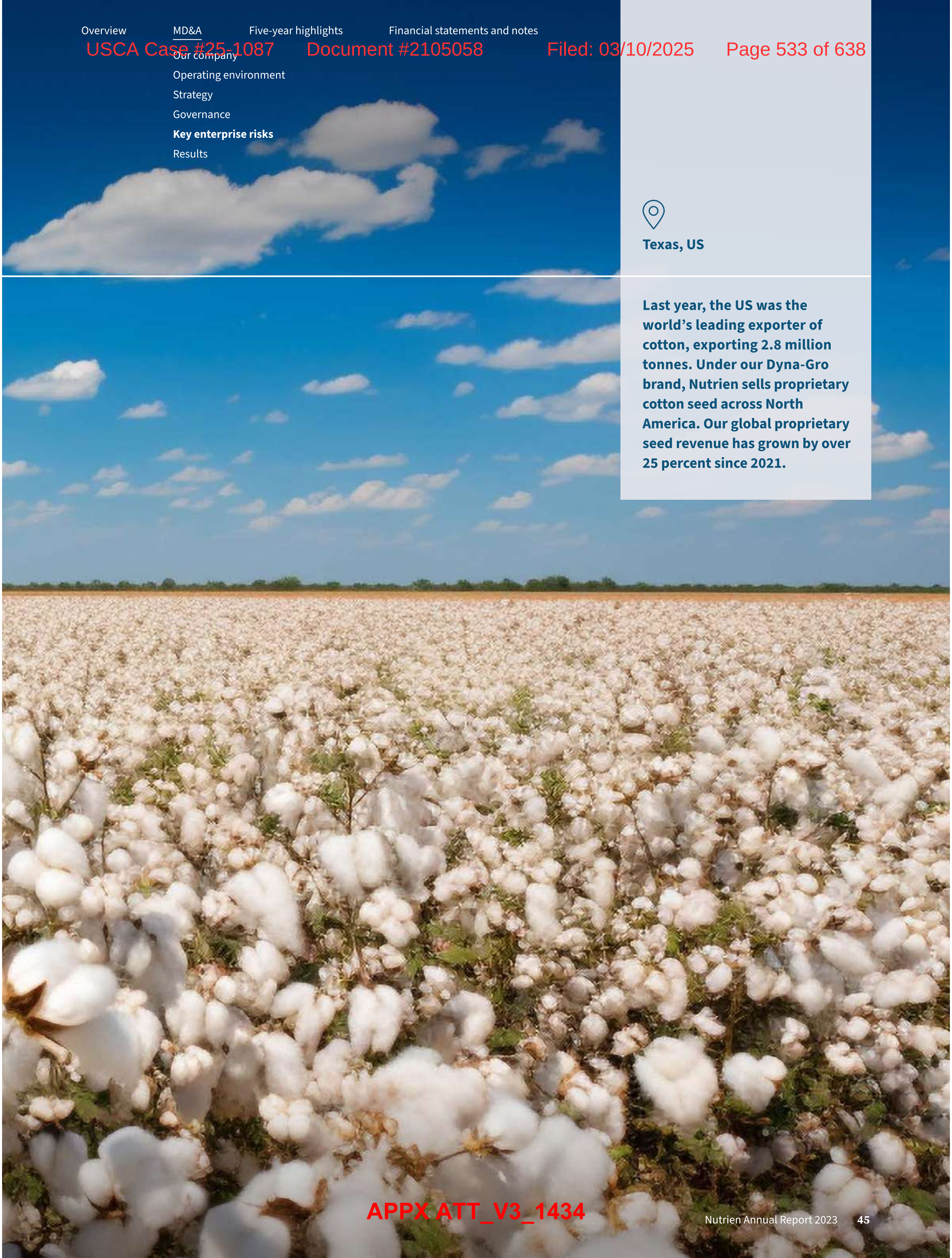
Risks are evaluated individually and collectively at the management level to fully understand Nutrien's risk landscape and identify interdependencies between risks. A consolidated view of our risks is presented to our ELT and senior leaders for review and discussion, along with outputs from external environment scans and emerging risk workshops. Nutrien's significant enterprise-wide risks are then presented to the Board at least annually.



05 Key enterprise risks

Texas, US

Last year, the US was the world's leading exporter of cotton, exporting 2.8 million tonnes. Under our Dyna-Gro brand, Nutrien sells proprietary cotton seed across North America. Our global proprietary seed revenue has grown by over 25 percent since 2021.



Key enterprise risks

Nutrien characterizes a key risk as a risk or combination of risks that could threaten the achievement of our vision, our business model, future financial performance or ability to deliver on our strategy. Our key enterprise risks are discussed below and while these represent our significant risks, we also continue to be exposed to other important general business, operational and climate-related risks. For a more detailed discussion of these key risks and other risks that may affect us, refer to Nutrien's 2023 Annual Information Form.

1 | Competition and shifting market fundamentals

Description
Global macroeconomic conditions and shifting market fundamentals – including trade tariffs and trade restrictions, volatility in global markets, supply chain constraints, increased price competition and/or new entrants, geopolitical conditions, and/or a significant change in agriculture production or consumption trends – could lead to a sustained environment of reduced demand for our products and/or low or volatile commodity prices and negatively impact our short- and long-term profitability.

Risk management approach
Our global footprint, integrated business, and portfolio of products, services and solutions are designed to enable us to respond to changing economic conditions. We have a favorable cost-structure and the flexibility to make operational changes across our portfolio in order to minimize the impact of changing market dynamics. We prioritize maintaining a strong balance sheet and focus on initiatives that strengthen the advantages of our integrated business, drive operational efficiencies and increase free cash flow.

2 | Agricultural changes and trends

Description
The following agriculture-related factors, among others, could impact our strategy, demand for our products and/or services and/or financial performance: farm and industry consolidation; shifting grower demographics; agriculture productivity and development; changes in consumer preferences; increasing focus on sustainability in agriculture (including soil health, availability of arable land, diminishing biodiversity and water management); and technological innovation and digital business models.

Risk management approach
Our global footprint, integrated business and diversified portfolio are designed to adapt to changes in the agriculture industry and help position us to drive long-term value creation and provide whole-acre solutions for growers. We are focused on optimizing our Retail business, digital innovation, growth in core markets and continued development of scalable sustainability programming.

See page 28 of this report for more information on our strategic priorities.

3 | Changing regulations

Description
Changing laws, regulations and government policies – including those relating to the environment and climate change, including regulation of GHG emissions, as well as health and safety laws or regulations, taxes and royalties – could affect our ability to produce or sell certain products, reduce our efficiency and competitive advantage, increase our costs of raw materials, energy, transportation and compliance, or require us to make capital improvements to our operations – all of which could impact our strategy, operations, financial performance or reputation.

Risk management approach
Our Government & Industry Affairs Team has an active engagement strategy with governments and regulators, including participation in industry associations. This allows us to keep current on regulatory developments affecting our business or industry, allowing us to anticipate new or changing laws and regulations and put us in the best position for success while leveraging our industry association allies.

We also have initiatives and commitments supporting product stewardship, and environment and climate action as part of our Feeding the Future Plan, to assist in managing the impact of potential regulatory changes.

4 | Climate change

Description
Climate change may cause or result in, among other things, more frequent and severe weather events, diminishing biodiversity, impacts to growing seasons or crop yields, and changing weather factors such as temperature, precipitation, wind and water levels, and affect freshwater availability. Physical risks from climate change may also result in operational or supply chain disruptions, depending on the nature of the event.

Impacts from transition risks could include, but are not limited to, policy constraints on emissions, carbon pricing mechanisms, water restrictions, land use restrictions or incentives, changing consumer preferences, and market demand and supply shifts. We are also subject to reputational risks associated with climate change, including our stakeholders' perception of the agriculture industry and our role in the transition to a lower-carbon economy. These and other factors resulting from climate change could adversely impact our business, financial condition, results of operations or liquidity.

Risk management approach
Our capital allocation framework and preventive maintenance programs help support the long-term reliability and efficiency of our assets. Additionally, our geographically diversified network of facilities and operations helps to minimize the overall impact of physical risk from climate change on our company.

For more information refer to page 7 of this report for our sustainability highlights and our most recent Global Sustainability Report on our website at **nutrien.com**, which is expected to be released in March 2024.

5 | Cybersecurity threats

Description
Cyberattacks, ransomware events, power outages, terrorist attacks, natural disasters, military conflicts, local epidemics or pandemics, other events, and breaches or exposure to potential computer viruses of our systems, third-party service providers' systems, or cloud-based platforms could lead to disruptions to our operations, loss of data or the unintended disclosure of confidential information and/or personally identifiable information or property damage. Any of these could result in business disruptions, increased defense costs, reputational damage, personal injury or third-party claims, impacting our operations, financial performance or reputation.

Risk management approach
Our Global Information Management and Cyber-Security Team is supported by third-party specialists, oversees our network security and may assist in incident response.

We promote a strong culture of cybersecurity awareness to minimize threats and vulnerabilities, which is supported by our cybersecurity framework, policies and best practices.

Threat and risk assessments are completed for all new information technology systems, and our cybersecurity incident response processes are backstopped by external response measures. We also conduct regular simulated phishing and targeted cybersecurity training as well as incident response training.

For more information refer to our most recent Global Sustainability Report on our website at **nutrien.com**, which is expected to be released in March 2024.

6 | Political, economic and social instability

Description
Political, economic and social instability may affect our business including, for instance, if any of the jurisdictions in which we operate or do business introduce restrictions on monetary distributions, labor disruptions, competitive restrictions, forced divestitures or changes to or nullification of existing agreements, mining permits or leases, or the imposition of tariffs, exchange controls, international trade restrictions, embargoes, barriers or other restrictions. Instability in political or regulatory regimes could also affect our ability to do business and could impact our sales and operating results, our reputation or the value of our assets.

Risk management approach
Our Government & Industry Affairs Team has an active engagement strategy with governments, regulators and other stakeholders in the countries where we operate or plan to operate. We assess capital investments and project decisions against political, country and other related risk factors and avoid or reduce our exposure to jurisdictions with unacceptable risk levels. Dedicated teams regularly monitor developments and global trends that may impact us.

7 | Talent and organization culture

Description
An inability to attract and retain qualified top talent, including for skillsets that are in high demand, could impact our business, financial condition and results of operations. Failure to provide the necessary organizational structure, programs and culture to engage and develop our employees, including providing a respectful, inclusive and diverse workplace, could impact our ability to achieve our growth objectives or expected business results.

Risk management approach
Our Talent Attraction and Sourcing Team focuses on building a diverse, inclusive and talented workforce. We are committed to the career development of our employees and building a culture grounded in our organizational purpose and the values of safety, inclusion, integrity and results. Our talent succession process focuses on identifying and managing critical roles and the proactive build-up of internal and external bench strength. Our incentive programs are competitive, performance-based and support our purpose-driven culture.

8 | Stakeholder support

Description
Our stakeholders may not support our business plans, structure, strategy, sustainability initiatives, or climate commitments and social responsibilities. Our inability to meet our sustainability and climate-related commitments and targets may also have an adverse effect on our stakeholder support, among others. Loss of stakeholder confidence could impair our ability to execute our business plans, negatively impact our ability to produce or sell our products, and may lead to reputational damage, increased costs, financial losses, securityholder action or negatively impact our access to or cost of capital.

Risk management approach
Our Investor Relations and Stakeholder Relations teams monitor and regularly engage with our stakeholders to identify their key issues and communicate the long-term value opportunities associated with our business. We also have an active Community Relations Team and community investment programs. Our Strategies and Feeding the Future Plan are structured to help support what matters most to our stakeholders.

9 | Supply chains

Description
Supply chain disruptions could result in difficulties supplying materials to our facilities and/or impair our ability (or the ability of the third parties upon which we rely) to deliver products to our customers in a timely manner. If certain key raw materials, parts and/or supplies used in our operations are not available, our business could be disrupted. Ongoing geopolitical conflicts, regulatory instability and changes to tariffs, epidemics, pandemics, or other such crises have created and could still create supply chain challenges and disruptions, and/or limit our ability to timely sell or distribute our products in the future, any of which could negatively impact our business, financial condition and operating results.

Risk management approach
Our integrated business provides us the flexibility to optimize operations, transportation and logistics, or increase supply chain efficiencies to adapt to potential disruption. We regularly review our suppliers to ensure we can maintain critical feedstocks and can leverage our diverse retail distribution network and expansive fertilizer terminal and transportation network to effectively manage product logistical challenges.

10 | Capital redeployment

Description
Our inability to deploy capital to efficiently achieve sustained growth, effectively execute on opportunities or meet investor preferences – whether due to market conditions, lack of options or otherwise, or deploying capital in a manner inconsistent with our strategic priorities – could impact our returns, operations, reputation, access to or cost of capital, or potential impairment charges related to the goodwill or intangible assets.

Risk management approach
We continue to focus on creating long-term value through a balanced and disciplined approach to capital allocation. We prioritize maintaining safe and reliable operations, a healthy balance sheet, investing in our business and providing strong returns to shareholders.

See page 35 of this report for more information on our capital allocation priorities and key actions during the year.

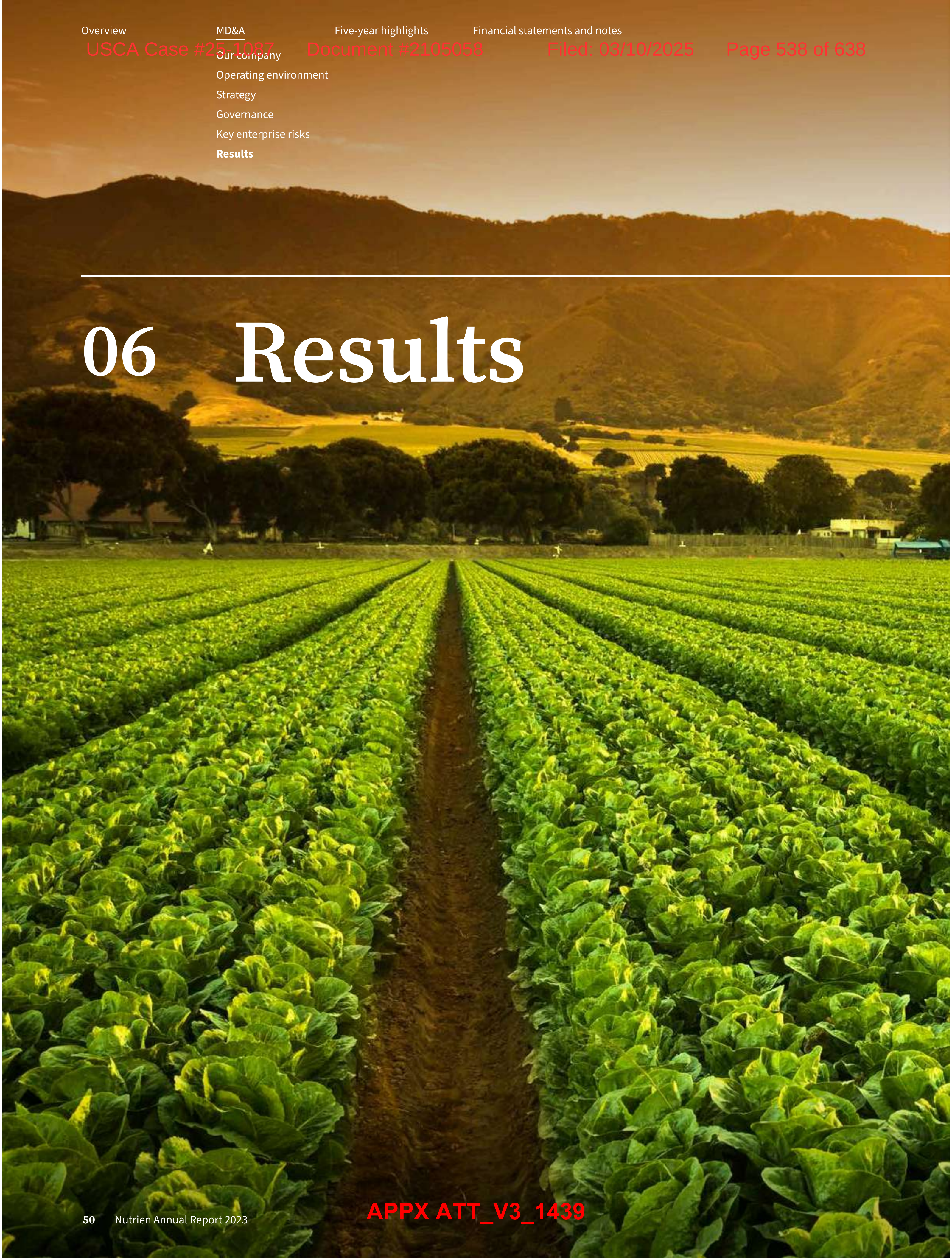
11 | Safety, health and environment

Description
Our operations are subject to safety, health and environmental risks inherent in mining, manufacturing, transportation, storage and distribution of our products. These factors could result in injuries or fatalities, or impact air quality, biodiversity, water resources or related ecosystems near our operations, impacting our operations, financial performance or reputation.

Risk management approach
Our safety strategy and governance processes ensure we follow all regulatory, industry and internal standards of safety, health and environmental responsibility that involve independent audits and assessments. We have structured incident prevention and response systems in place and conduct regular security vulnerability assessments. We have crisis communication protocols and emergency response programs across our business and maintain environmental monitoring and control systems, including third-party reviews of key containment structures.

For more information refer to our most recent Global Sustainability Report on our website at **nutrien.com**, which is expected to be released in March 2024.

06 Results



California, US

The US is the world's second largest producer of lettuce. Nutrien's network of ~1,200 selling locations in the US serves growers needs including specialty crops like lettuce and other fruits and vegetables.

- Adjusted EBITDA is the primary profit measure used to evaluate the segments' performance as it excludes the impact of non-cash impairments and impairment reversals and other costs that are centrally managed by our corporate function. Refer to Note 3 to the consolidated financial statements for details.

- Net sales (sales less freight, transportation and distribution expenses) is the primary revenue measure used in planning and forecasting in the Potash, Nitrogen and Phosphate operating segments.

R | 2023 Nutrien Ag Solutions ("Retail") financial performance

Our Retail business generated adjusted EBITDA of $1.5 billion, lower than the record levels of the prior year primarily due to lower gross margin for both crop nutrients and crop protection products. Margins were pressured as crop input prices softened and higher cost inventory moved through the channel. Crop nutrients sales volumes increased by over 1 million tonnes as growers worked to replenish nutrients in the soil. As the year progressed, crop input margins in North America normalized and customers returned to more normal buying behaviors.

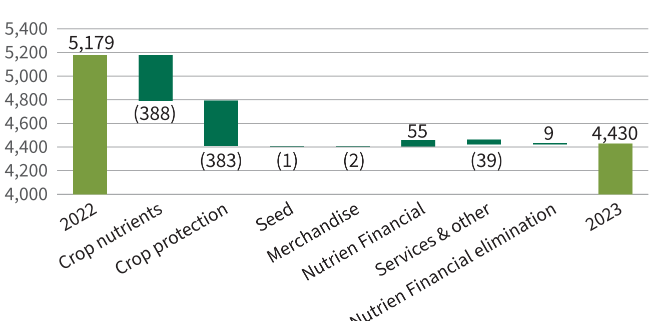
In Brazil, we saw continued margin compression due to decreased prices for certain crop protection products and the selling through of high cost inventory. Included with expenses for the full year of 2023, we recognized a $465 million non-cash impairment primarily to goodwill relating to our Retail – South America assets, mainly due to the impact of crop input price volatility, more moderate long-term growth assumptions and higher interest rates. We believe the long-term prospects for agriculture in Brazil are strong and it remains an important crop input market for Nutrien. In the near-term, we are focused on integration of our recent acquisitions and optimization of our cost structure in this region.

	Dollars			Gross margin			Gross margin (%)	
(millions of US dollars, except as otherwise noted)	2023	2022	% Change	2023	2022	% Change	2023	2022
Sales								
Crop nutrients	8,379	10,060	(17)	1,378	1,766	(22)	16	18
Crop protection products	6,750	7,067	(4)	1,553	1,936	(20)	23	27
Seed	2,295	2,112	9	427	428	–	19	20
Merchandise	1,001	1,019	(2)	172	174	(1)	17	17
Nutrien Financial	322	267	21	322	267	21	100	100
Services and other	927	966	(4)	710	749	(5)	77	78
Nutrien Financial elimination [1]	(132)	(141)	(6)	(132)	(141)	(6)	100	100
	19,542	21,350	(8)	4,430	5,179	(14)	23	24
Cost of goods sold	15,112	16,171	(7)					
Gross margin	4,430	5,179	(14)					
Expenses [2,3]	4,215	3,621	16					
Earnings before finance costs and taxes ("EBIT")	215	1,558	(86)					
Depreciation and amortization	759	752	1					
EBITDA	974	2,310	(58)					
Adjustments [3]	485	(17)	n/m					
Adjusted EBITDA	1,459	2,293	(36)					

1 Represents elimination of the interest and service fees charged by Nutrien Financial to Retail branches.
2 Includes selling expenses of $3,375 million (2022 – $3,392 million).
3 Includes non-cash impairment of assets of $465 million (2022 – nil). See Notes 3 and 14 to the consolidated financial statements.

Retail gross margin changes by product

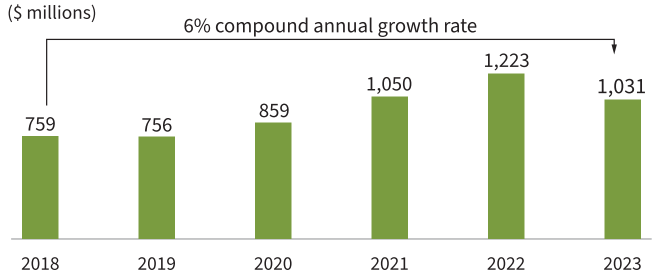
($ millions)



Source: Nutrien

Proprietary products gross margin

($ millions)



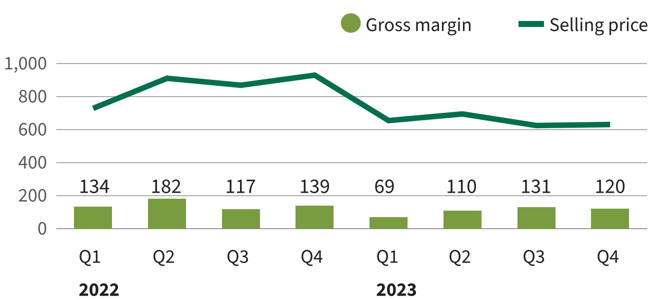
Source: Nutrien

The most significant contributors to the changes in our Retail financial performance were as follows:

	2023 vs 2022
Crop nutrients	Sales and gross margin decreased in 2023 due to lower selling prices across all regions compared to the strong comparable period in 2022. Sales volumes increased in 2023 as growers returned to more normalized application rates to replenish nutrients in the soil. Sales and gross margin of our proprietary nutritional and biostimulant product lines increased compared to 2022 levels as we continued to expand our differentiated product offering and manufacturing capacity.
Crop protection products	Sales and gross margin were lower primarily due to decreased selling prices compared to the historically strong comparable period in 2022. This was partially offset by higher fourth quarter sales in North America as growers returned to more normalized buying behaviors. Gross margin in 2023 was also impacted by the selling through of high-cost inventory.
Seed	Sales increased in 2023 primarily due to increased corn sales in the US, while gross margin saw little change compared to 2022.
Nutrien Financial	Sales increased in 2023 due to higher utilization of our financing offerings in the US and Australia compared to 2022.
Services and other	Sales and gross margin decreased in 2023 mainly due to lower livestock selling prices and volumes in Australia.
Expenses	In 2023, we recognized a $465 million non-cash impairment primarily to goodwill related to our Retail – South America assets, mainly due to the impact of crop input price volatility, more moderate long-term growth assumptions and higher interest rates. Selling expenses as a percentage of sales were higher in 2023 primarily due to lower selling prices compared to the strong comparable period in 2022.
Adjusted EBITDA	Adjusted EBITDA decreased in 2023 primarily due to lower gross margins for crop nutrients and crop protection products.

Retail crop nutrient gross margin and selling price

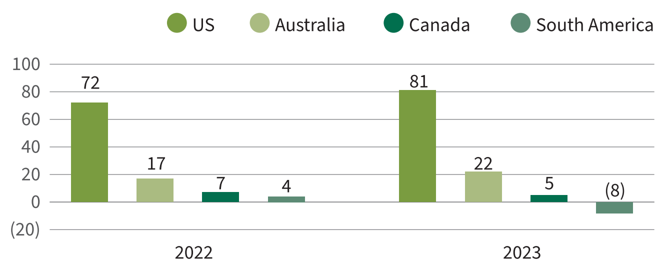
($ per tonne)



Source: Nutrien

Contribution to adjusted EBITDA by market

(percent)



Source: Nutrien

Selected Retail measures

	2023	2022
Proprietary products gross margin (millions of US dollars)		
Crop nutrients	391	370
Crop protection products	461	675
Seed	168	166
Merchandise	11	12
All products	1,031	1,223
Proprietary products margin as a percentage of product line margin (%)		
Crop nutrients	28	21
Crop protection products	30	35
Seed	39	39
Merchandise	6	7
All products	23	24

	2023	2022
Crop nutrients sales volumes (tonnes – thousands)		
North America	8,985	8,106
International	3,647	3,407
Total	12,632	11,513
Crop nutrients selling price per tonne		
North America	697	916
International	581	774
Total	663	874
Crop nutrients gross margin per tonne		
North America	127	182
International	65	86
Total	109	153
Financial performance measures	**2023**	**2022**
Retail adjusted EBITDA margin (%) [1]	7	11
Retail adjusted EBITDA per US selling location (thousands of US dollars) [1,2]	1,394	1,923
Retail adjusted average working capital to sales (%) [3]	19	17
Retail adjusted average working capital to sales excluding Nutrien Financial (%) [3]	1	2
Nutrien Financial adjusted net interest margin (%) [3]	5.2	6.8
Retail cash operating coverage ratio (%) [3]	68	55

1 These are supplementary financial measures. See the "Other Financial Measures" section.
2 Excluding acquisitions.
3 These are non-GAAP financial measures. See the "Non-GAAP Financial Measures" section.

Nutrien Financial

We offer flexible financing solutions to our customers in support of Nutrien's agricultural product and service sales. Qualifying Retail customers in the US and Australia are offered extended payment terms, typically up to one year, to facilitate the alignment of grower crop cycles with cash flows. Nutrien Financial revenues are primarily earned through interest and service fees that are charged to our Retail branches.

We hold a significant portion of receivables from customers that have historically experienced a low-default rate. We manage our credit portfolio based on a combination of review of customer credit metrics, past experience with the customer and exposure to any single customer. Nutrien Financial, which is our wholly owned finance captive, monitors and services the portfolio of our high-quality receivables from customers that have the lowest risk of default among Retail's receivables from customers. We monitor the results of this portfolio of receivables separately because we calculate the cost of capital attributable to the high-quality receivables from customers differently from our other receivables. Specifically, we assume a debt-to-equity ratio of 7:1 in funding Nutrien Financial receivables, based on the underlying credit quality of the assets.

Nutrien Financial relies on corporate capital for funding. For 2023, we estimated the deemed interest expense using an average borrowing rate of 4.1 percent (2022 - 1.4 percent) applied to the notional debt required to fund the portfolio of receivables from customers monitored and serviced by Nutrien Financial. The balance of our Retail receivables (outside of Nutrien Financial) is subject to marginally higher credit risk.

			As at December 31					
(millions of US dollars)	**Current**	**<31 Days past due**	**31–90 Days past due**	**>90 Days past due**	**Gross receivables**	**Allowance [1]**	**2023 Net receivables**	**2022 Net receivables**
North America	1,736	327	89	94	2,246	(40)	2,206	2,007
International	560	56	22	59	697	(10)	687	662
Nutrien Financial receivables [2]	2,296	383	111	153	2,943	(50)	2,893	2,669

1 Bad debt expense on the above receivables for the twelve months ended December 31, 2023 was $35 million (2022 – $10 million) in the Retail segment.
2 Gross receivables include $2,578 million (2022 – $2,260 million) of very low risk of default and $365 million (2022 – $445 million) of low risk of default.

K | 2023 Potash financial performance

Our Potash business delivered adjusted EBITDA of $2.4 billion as lower net realized selling prices more than offset higher North American sales volumes and lower provincial mining taxes and royalties. Potash sales volumes in North America increased due to lower channel inventory and increased grower demand supported by an extended fall application season and improved affordability. Offshore sales volumes were lower compared to last year's record levels primarily due to logistical challenges at Canpotex's West Coast port facilities and reduced shipments to customers in India and Southeast Asia.

	Dollars			Tonnes (thousands)			Average per tonne		
(millions of US dollars, except as otherwise noted)	2023	2022	% Change	2023	2022	% Change	2023	2022	% Change
Manufactured product									
Net sales									
North America	1,683	2,485	(32)	4,843	3,729	30	348	667	(48)
Offshore	2,076	5,414	(62)	8,373	8,808	(5)	248	615	(60)
	3,759	7,899	(52)	13,216	12,537	5	284	630	(55)
Cost of goods sold	1,396	1,400	–				105	112	(6)
Gross margin – total	2,363	6,499	(64)				179	518	(65)
Expenses [1]	422	1,173	(64)	Depreciation and amortization			35	35	–
EBIT	1,941	5,326	(64)	Gross margin excluding depreciation and amortization –manufactured [2]			214	553	(61)
Depreciation and amortization	463	443	5						
EBITDA/Adjusted EBITDA	2,404	5,769	(58)	Potash controllable cash cost of product manufactured [2]			58	58	–

1 Includes provincial mining taxes of $398 million (2022 – $1,149 million).
2 These are non-GAAP financial measures. See the "Non-GAAP Financial Measures" section.

The most significant contributors to the changes in our Potash financial performance were as follows:

	2023 vs 2022
Sales volumes	Overall sales volumes were higher in 2023. North America sales volumes increased in 2023 due to lower channel inventory and increased grower demand supported by an extended fall application season and improved affordability. Offshore sales volumes were lower in 2023 compared to record levels in 2022 primarily due to logistical challenges at Canpotex's West Coast port facilities and reduced shipments to customers in India and Southeast Asia.
Net realized selling price	Average net realized selling prices decreased in 2023 compared to the historically strong prices in 2022 due to a decline in benchmark prices and higher costs related to logistical challenges at Canpotex's West Coast port facilities.
Cost of goods sold per tonne	Costs decreased in 2023 mainly due to lower royalties resulting from decreased net realized selling prices. Potash controllable cash cost of product manufactured per tonne was consistent with 2022.
Expenses	Expenses decreased in 2023 primarily due to lower provincial mining taxes from lower average potash selling prices, which are the basis for certain taxes. We are subject to Saskatchewan provincial resource taxes, including the potash production tax and the resource surcharge.
Adjusted EBITDA	Adjusted EBITDA decreased in 2023 due to lower net realized selling prices, which more than offset higher North American sales volumes and lower provincial mining taxes and royalties.

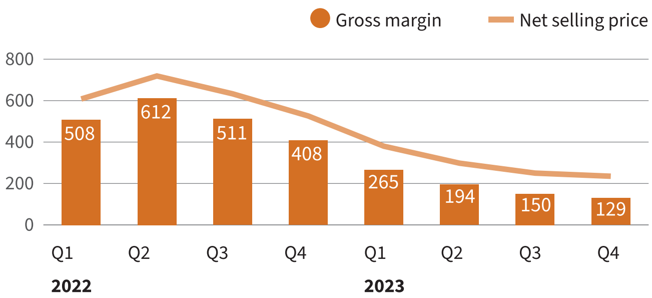
Canpotex sales by market

(percentage of sales volumes, except as otherwise noted)	2023	2022	Change
Latin America	47	34	13
Other Asian markets [1]	28	34	(6)
Other markets	11	10	1
China	9	14	(5)
India	5	8	(3)

1 All Asian markets except China and India.

Potash gross margin and net selling price

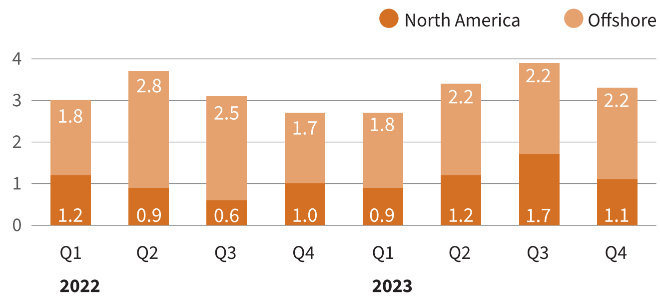
($ per tonne)



Source: Nutrien

Potash sales volumes

(million tonnes)



Source: Nutrien

Potash production

(million tonnes KCl)	Nameplate capacity [1]	Operational capability [2] 2024	Operational capability [2] 2023	Production 2023	Production 2022
Rocanville Potash	6.5	5.1	5.2	4.97	4.89
Allan Potash	4.0	2.4	3.0	2.39	2.50
Lanigan Potash	3.8	3.0	3.1	2.89	2.46
Vanscoy Potash	3.0	1.1	1.4	1.05	1.01
Cory Potash	3.0	2.1	2.2	1.50	1.89
Patience Lake Potash	0.3	0.3	0.3	0.20	0.26
Total	20.6	14.0	15.2	13.00	13.01
Shutdown weeks [3]				5	18

1 Represents estimates of capacity as at December 31, 2023. Estimates based on capacity as per design specifications or Canpotex entitlements once determined. In the case of Patience Lake, estimate reflects current operational capability. Estimates for all other facilities do not necessarily represent operational capability.
2 Estimated annual achievable production based on expected staffing and operational readiness (estimated at the beginning of the year, and may vary during the year, and year-to-year, including between our facilities). Estimate does not include inventory-related shutdowns and unplanned downtime.
3 Represents weeks of full production shutdown, excluding the impact of any periods of reduced operating rates and planned routine annual maintenance shutdowns and announced workforce reductions.

N | 2023 Nitrogen financial performance

We generated adjusted EBITDA of $1.9 billion for our Nitrogen business, below the record levels of the prior year due to lower net realized selling prices for all major nitrogen products, which more than offset lower natural gas costs and higher sales volumes. Our increased sales volumes were primarily due to higher UAN production and sales, partially offset by lower ammonia availability mainly due to production outages at our plants in Trinidad. We recognized a $76 million non-cash impairment of our Trinidad property, plant and equipment due to a new natural gas contract and the resulting outlook for higher expected natural gas costs and constrained near-term availability. We expect improved natural gas availability in Trinidad as the development of additional gas fields is anticipated to add new supply starting in 2026.

	Dollars			Tonnes (thousands)				Average per tonne		
(millions of US dollars, except as otherwise noted)	2023	2022	% Change	2023	2022	% Change		2023	2022	% Change
Manufactured product										
Net sales										
Ammonia	1,144	2,641	(57)	2,436	2,715	(10)		469	973	(52)
Urea and ESN® [1]	1,499	2,134	(30)	3,125	3,014	4		480	708	(32)
Solutions, nitrates and sulfates	1,187	1,829	(35)	4,862	4,551	7		244	402	(39)
	3,830	6,604	(42)	10,423	10,280	1		367	642	(43)
Cost of goods sold [1]	2,435	3,370	(28)					233	327	(29)
Gross margin – manufactured	1,395	3,234	(57)					134	315	(57)
Gross margin – other [1,2]	(16)	47	n/m				Depreciation and amortization	55	54	2
Gross margin – total	1,379	3,281	(58)				Gross margin excluding depreciation and amortization – manufactured [5]	189	369	(49)
Expenses (income) [3,4]	97	(92)	n/m							
EBIT	1,282	3,373	(62)				Ammonia controllable cash cost of product manufactured [5]	60	59	2
Depreciation and amortization	572	558	3							
EBITDA/Adjusted EBITDA	1,854	3,931	(53)							
Adjustments [4]	76	–	n/m							
Adjusted EBITDA	1,930	3,931	(51)							

1 Certain immaterial 2022 figures have been reclassified.
2 Includes other nitrogen and purchased products and comprises net sales of $377 million (2022 – $929 million) less cost of goods sold of $393 million (2022 –$882 million).
3 Includes earnings from equity-accounted investees of $90 million (2022 – $233 million).
4 Includes non-cash impairment of assets of $76 million (2022 – nil). See Notes 3 and 13 to the consolidated financial statements.
5 These are non-GAAP financial measures. See the “Non-GAAP Financial Measures” section.

The most significant contributors to the changes in our Nitrogen financial performance were as follows:

	2023 vs 2022
Sales volumes	Sales volumes were higher in 2023 primarily due to higher UAN production and sales, partially offset by lower ammonia availability mainly due to production outages at our plants in Trinidad.
Net realized selling price	Net realized selling price was lower in 2023 for all major nitrogen products primarily due to weaker benchmark prices resulting from lower energy prices in key nitrogen producing regions.
Cost of goods sold per tonne	Costs decreased in 2023 primarily due to lower natural gas costs. Raw materials and other input costs were also lower in 2023 compared to 2022 due to lower benchmark prices. Ammonia controllable cash cost of product manufactured per tonne increased mainly due to the impact of lower ammonia production.
Expenses (income)	We recognized a $76 million non-cash impairment of our Trinidad property, plant and equipment due to a new natural gas contract and the resulting outlook for higher expected natural gas costs and constrained near-term availability. We expect improved natural gas availability in Trinidad as the development of additional gas fields is anticipated to add new supply starting in 2026. There was no comparable expense in 2022. Other expenses (income) also increased in 2023 mainly due to lower earnings from our equity-accounted investment in Profertil. Profertil's earnings were lower mainly due to lower urea net selling prices from lower benchmark prices.
Adjusted EBITDA	Adjusted EBITDA was lower in 2023 primarily due to lower net realized selling prices for all major nitrogen products, which more than offset lower natural gas costs and higher sales volumes.

Natural gas prices in cost of production

(US dollars per MMBtu, except as otherwise noted)	2023	2022	% Change
Overall natural gas cost excluding realized derivative impact	3.51	7.82	(55)
Realized derivative impact	(0.02)	(0.05)	(60)
Overall natural gas cost	3.49	7.77	(55)
Average NYMEX	2.74	6.64	(59)
Average AECO	2.17	4.28	(49)

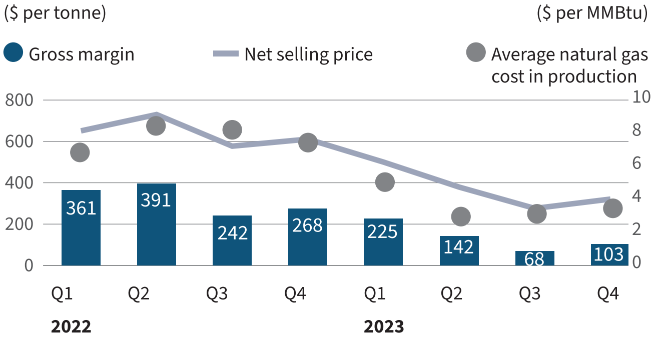
	2023 vs 2022
Overall natural gas cost	Natural gas prices in our cost of production decreased in 2023 as a result of lower North American natural gas index prices and decreased natural gas costs in Trinidad, where our natural gas prices are linked to ammonia benchmark prices.

Selected Nitrogen measures

	2023	2022
Sales volumes (tonnes – thousands)		
Fertilizer [1]	6,067	5,628
Industrial and feed	4,356	4,652
Net sales (millions of US dollars)		
Fertilizer [1]	2,450	3,726
Industrial and feed	1,380	2,878
Net selling price per tonne		
Fertilizer [1]	404	662
Industrial and feed	317	619

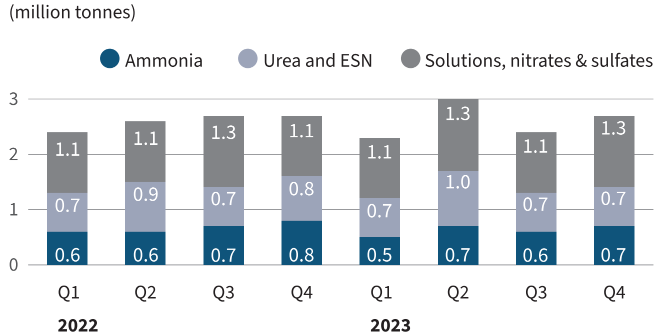
1 Certain immaterial 2022 figures have been reclassified.

Nitrogen gross margin, net selling price and natural gas cost



Source: Nutrien

Nitrogen sales volumes



Source: Nutrien

Nitrogen production

(million tonnes product, except as otherwise noted)	Ammonia [1] Annual capacity [3]	Ammonia [1] Production 2023	Ammonia [1] Production 2022	Urea [2] Annual capacity [3]	Urea [2] Production 2023	Urea [2] Production 2022
Trinidad Nitrogen [4]	2.2	1.11	1.46	0.7	0.32	0.42
Redwater Nitrogen	0.9	0.89	0.78	0.7	0.76	0.55
Augusta Nitrogen	0.8	0.74	0.59	0.7	0.56	0.40
Lima Nitrogen	0.7	0.68	0.71	0.5	0.51	0.50
Geismar Nitrogen	0.5	0.43	0.58	0.4	0.30	0.37
Carseland Nitrogen	0.5	0.53	0.39	0.7	0.75	0.50
Fort Saskatchewan Nitrogen	0.5	0.39	0.47	0.4	0.35	0.44
Borger Nitrogen	0.5	0.24	0.41	0.6	0.31	0.49
Joffre Nitrogen	0.5	0.34	0.37	–	–	–
Total	7.1	5.35	5.76	4.7	3.86	3.67
Adjusted total [5]		3.90	3.93			
Ammonia operating rate [5] (%)		88	90			

1 All figures are shown on a gross production basis.
2 Reflects capacity and production of urea liquor prior to final product upgrade. Urea liquor is used in the production of solid urea, UAN and DEF.
3 Annual capacity estimates include allowances for normal operating plant conditions.
4 In 2022 and 2023, Trinidad production was restricted due to natural gas curtailments, which are expected to extend into 2024.
5 Excludes Trinidad and Joffre.

P | 2023 Phosphate financial performance

Our Phosphate business earned adjusted EBITDA of $470 million, lower compared to the prior year mainly due to lower net realized selling prices for fertilizer products, partially offset by lower ammonia and sulfur input costs. Our sales volumes increased primarily due to higher phosphate fertilizer demand, partially offset by lower first-half production impacting our industrial and feed sales. Our production was higher for the full year largely due to improved reliability at our Aurora plant. Included in the expenses for the full year of 2023, we recognized a $233 million non-cash impairment of our White Springs property, plant and equipment, while we had non-cash impairment reversals of our Phosphate assets of $780 million for the full year of 2022.

(millions of US dollars, except as otherwise noted)	Dollars 2023	Dollars 2022	Dollars % Change
Manufactured product			
Net sales			
Fertilizer	1,085	1,367	(21)
Industrial and feed	645	706	(9)
	1,730	2,073	(17)
Cost of goods sold	1,487	1,562	(5)
Gross margin – manufactured	243	511	(52)
Gross margin – other [1]	(10)	(18)	(44)
Gross margin – total	233	493	(53)
Expenses (income)	290	(693)	n/m
EBIT	(57)	1,186	n/m
Depreciation and amortization	294	188	56
EBITDA	237	1,374	(83)
Adjustments [3]	233	(780)	n/m
Adjusted EBITDA	470	594	(21)

	Tonnes (thousands) 2023	Tonnes (thousands) 2022	Tonnes (thousands) % Change	Average per tonne 2023	Average per tonne 2022	Average per tonne % Change
Fertilizer	1,912	1,696	13	568	806	(30)
Industrial and feed	639	682	(6)	1,010	1,035	(2)
	2,551	2,378	7	678	872	(22)
Cost of goods sold				583	657	(11)
Gross margin – manufactured				95	215	(56)
Depreciation and amortization				115	79	46
Gross margin excluding depreciation and amortization – manufactured [2]				210	294	(29)

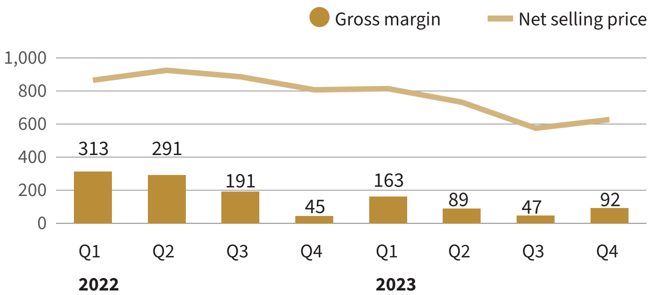
1 Includes other phosphate and purchased products and comprises net sales of $263 million (2022 – $304 million) less cost of goods sold of $273 million (2022 – $322 million).
2 This is a non-GAAP financial measure. See the "Non-GAAP Financial Measures" section.
3 Includes non-cash impairment of assets of $233 million (2022 – reversal of non-cash impairment of assets of $780 million). See Notes 3 and 13 to the consolidated financial statements.

The most significant contributors to the changes in our Phosphate financial performance were as follows:

	2023 vs 2022
Sales volumes	Sales volumes increased in 2023 mostly due to higher phosphate fertilizer demand, partially offset by lower first-half year production impacting our industrial and feed sales. Production increased in 2023 largely due to improved reliability at our Aurora plant.
Net realized selling price	Net realized selling prices decreased in 2023 primarily due to lower fertilizer net realized selling prices and lower industrial and feed net realized selling prices, which reflect the typical lag in price realizations relative to spot fertilizer prices.
Cost of goods sold per tonne	Costs decreased in 2023 mainly due to lower ammonia and sulfur input costs, partially offset by higher depreciation and amortization resulting from the reversal of non-cash impairment of assets in 2022 (see details below).
Expenses (income)	In 2023, we recognized a $233 million non-cash impairment of our White Springs property, plant and equipment, while we had non-cash impairment reversals of our Phosphate assets of $780 million in 2022. The impairments and impairment reversals were due to changes in our forecasted global prices driven by the prevailing macroeconomic environment.
Adjusted EBITDA	Adjusted EBITDA decreased in 2023 mainly due to lower net realized selling prices for fertilizer products, partially offset by lower ammonia and sulfur input costs.

Phosphate gross margin and net selling price

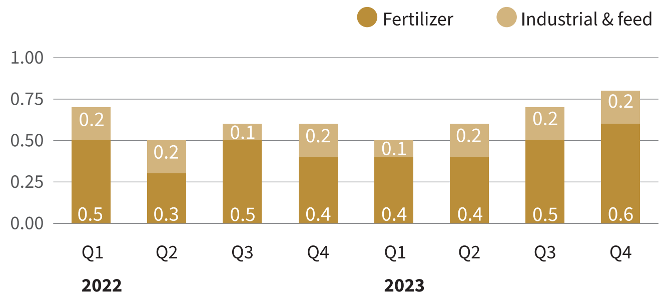
($ per tonne)



Source: Nutrien

Phosphate sales volumes

(million tonnes)



Source: Nutrien

Phosphate production

(million tonnes, except as otherwise noted)	Phosphate rock Annual capacity	Phosphate rock Production 2023	Phosphate rock Production 2022	Phosphoric acid (P_2O_5) Annual capacity	Phosphoric acid (P_2O_5) Production 2023	Phosphoric acid (P_2O_5) Production 2022	Liquid products Annual capacity	Liquid products Production 2023	Liquid products Production 2022	Solid fertilizer products Annual capacity	Solid fertilizer products Production 2023	Solid fertilizer products Production 2022
Aurora Phosphate	5.4	4.24	3.43	1.2	1.00	0.93	2.7 [1]	2.13	1.87	0.8	0.77	0.68
White Springs Phosphate	2.0	1.27	1.42	0.5	0.40	0.42	0.7 [2]	0.33	0.39	0.8	0.33	0.30
Total	7.4	5.51	4.85	1.7	1.40	1.35	3.4	2.46	2.26	1.6	1.10	0.98
P_2O_5 operating rate (%)					83	79						

1 A substantial portion is consumed internally in the production of downstream products. The balance is exported to phosphate fertilizer producers or sold domestically to dealers who custom-mix liquid fertilizer. Capacity is composed of 2.0 million tonnes MGA and 0.7 million tonnes SPA.

2 Represents annual SPA capacity. A substantial portion is consumed internally in the production of downstream products. The balance is exported to phosphate fertilizer producers or sold domestically to dealers who custom-mix liquid fertilizer.

In addition to the production above, annual capacity (in millions of tonnes) for phosphate feed and purified acid was 0.7 and 0.3, respectively. Production in 2023 was 0.30 and 0.16, respectively, and 2022 production was 0.33 and 0.18, respectively.

2023 Corporate and Others financial performance

"Corporate and Others" is a non-operating segment comprising corporate and administrative functions that provide support and governance to our operating segments.

(millions of US dollars, except as otherwise noted)	2023	2022	% Change
Selling expense (recovery)	–	(1)	n/m
General and administrative expenses	364	326	12
Share-based compensation (recovery) expense	(14)	63	n/m
Other expenses	348	227	53
EBIT	(698)	(615)	13
Depreciation and amortization	81	71	14
EBITDA	(617)	(544)	13
Adjustments [1]	350	146	140
Adjusted EBITDA	(267)	(398)	(33)

1 See Note 3 to the consolidated financial statements.

The most significant contributors to the changes in our Corporate and Others financial performance were as follows:

	2023 vs 2022
General and administrative expenses	Increase in expenses was primarily due to higher staffing costs and higher depreciation and amortization expense.
Share-based compensation (recovery) expense	Recovery in 2023 was due to decrease in the fair value of share-based awards outstanding relative to 2022. The fair value takes into consideration several factors such as our share price movement, our performance relative to our peer group and return on our invested capital.
Other expenses	Increase in other expenses was mainly due to a $152 million higher expense related to asset retirement obligations and environmental costs resulting from changes in estimates related to our non-operating sites and a $92 million loss on Blue Chip Swaps incurred through trade transactions to remit cash from Argentina and higher foreign exchange losses in 2023. These expenses were partially offset by an $80 million gain in 2023 from amendments due to design plan changes to our other post-retirement benefit plans. Refer to Note 6 to the consolidated financial statements for details on the loss on Blue Chip Swaps.

Eliminations

Eliminations are not part of the Corporate and Others segment. Eliminations of sales between operating segments in 2023 were $1,650 million (2022 – $2,333 million) with a gross margin recovery of $69 million (2022 – $28 million elimination). These variances are due to lower intersegment selling prices and margins in 2023 as crop input prices decreased compared to the historical strong prices of 2022.

Finance costs, income taxes and other comprehensive income (loss)

(millions of US dollars, except as otherwise noted)	2023	2022	% Change
Finance costs	793	563	41
Income tax expense	670	2,559	(74)
Other comprehensive income (loss)	81	(177)	n/m

The most significant contributors to the changes in our finance costs, income tax expense and other comprehensive income (loss) were as follows:

	2023 vs 2022
Finance costs	Finance costs increased primarily due to higher interest rates and higher average long-term debt balances.

Weighted Average Debt Balances and Rates
(millions of US dollars, except as otherwise noted)

	2023	2022
Short-term balance [1]	3,988	3,975
Short-term rate (%) [1]	6.1	3.0
Long-term balance (excluding lease obligations)	9,112	7,839
Long-term rate (excluding lease obligations) (%)	5.0	4.6
Lease obligations balance	1,200	1,209
Lease obligations rate (%)	4.0	2.9

1 North American weighted average short-term debt balances were $3,306 million (2022 – $3,529 million) and rates were 5.6 percent (2022 – 2.6 percent).

Income tax expense

Income tax expense was lower in 2023 primarily as a result of lower earnings compared to 2022. The 2023 expense and effective tax rate reflect a $134 million income tax recovery due to changes to our tax declarations in Switzerland ("Swiss Tax Reform adjustment", refer to Note 8 to the consolidated financial statements for additional information) and a $101 million income tax expense due to a change in recognition of deferred tax assets in our Retail – South America region. The 2023 effective tax rate also includes the impact of our losses in Retail – South America, wherein we did not recognize a corresponding deferred tax asset as it did not meet the accounting criteria for asset recognition.

Effective tax rates and discrete items
(millions of US dollars, except as otherwise noted)

	2023	2022
Actual effective tax rate on earnings (%)	33	25
Actual effective tax rate including discrete items (%)	34	25
Discrete tax adjustments that impacted the rate	28	30

Other comprehensive income (loss)

Other comprehensive income (loss) was primarily driven by changes in the currency translation of our Retail foreign operations primarily due to improvements of Canadian and Australian currencies relative to the US dollar in 2023. In 2023, we also recognized an actuarial gain on our defined benefit plans compared to a loss on the comparative period driven by changes in our financial and demographic assumptions and performance of our plan assets.

Performance against 2023 targets

Executing on our financial and operating targets

In 2019, we set ambitious targets for 2023 focused on growing and improving the quality of our Retail earnings, increasing our potash and nitrogen volumes, and controlling our operating costs. These targets were designed to motivate our teams and align our strategies with our vision and values. We made progress towards achieving these targets during this period, however geopolitical events, supply chain disruptions and inflationary pressures impacted our results in 2023. As we enter 2024, we remain focused on our core business, improving the quality of our earnings, investing in high-value strategic initiatives and fortifying our business for the future.

	2023 Target	2023 Actuals	2022 Actuals
Nutrien Ag Solutions ("Retail")			
Total Retail adjusted EBITDA margin (%) [1]	>10.5	7.5	10.7
US Retail adjusted EBITDA margin (%) [1,2]		9.3	12.2
Retail adjusted average working capital to sales (%) [3]	17	19	17
Retail cash operating coverage ratio (%) [3]	60	68	55
Retail adjusted EBITDA per US selling location (thousands of US dollars) [1,4]	>1,100	1,394	1,923
Retail proprietary products as a % of total Retail margin	29	23	24
Potash and Nitrogen			
Potash sales volumes (million tonnes)	14.0-16.0	13.2	12.5
Potash controllable cash cost of product manufactured per tonne (US dollars) [2,3]		58	58
Nitrogen sales volumes (million tonnes) [5]	10.8-11.4	10.4	10.3
Ammonia operating rate (%) [6]	96	88	90
Ammonia controllable cash cost of product manufactured per tonne (US dollars) [3]	42	60	59
IFRS comparable information			
Potash cost of goods sold (million US dollars) [2]		1,396	1,400
Nitrogen manufactured cost of goods sold (million US dollars) [2]		2,435	3,370

1 This is a supplementary financial measure. See the "Other Financial Measures" section.
2 No target was provided.
3 This is a non-GAAP financial measure. See the "Non-GAAP Financial Measures" section.
4 Calculation is based on number of selling locations only, excluding acquisitions.
5 Includes manufactured product only. 2023 target includes ESN® products that prior to 2022 were included in the other category.
6 Operating rate represents production volumes divided by production capacity (excluding Joffre and Trinidad facilities).

2024 Guidance

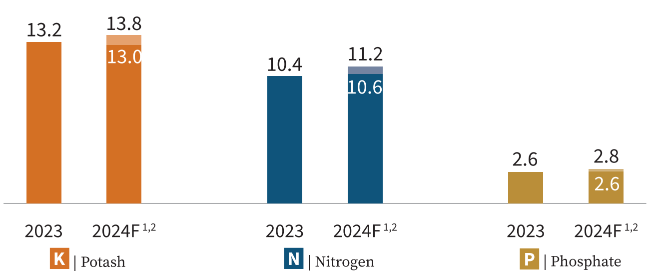
We have revised our guidance practice in 2024 to provide forward looking estimates on those metrics that we believe are of value to our shareholders and are less impacted by fertilizer commodity prices. We continue to provide guidance for Retail adjusted EBITDA, fertilizer sales volumes and other key financial modeling metrics as well as fertilizer pricing sensitivities.

	2024 Guidance Ranges[1] as of February 21, 2024		
(billions of US dollars, except as otherwise noted)	**Low**	**High**	**2023 Actual**
Retail adjusted EBITDA	1.65	1.85	1.5
Potash sales volumes (million tonnes) [2]	13.0	13.8	13.2
Nitrogen sales volumes (million tonnes) [2]	10.6	11.2	10.4
Phosphate sales volumes (million tonnes) [2]	2.6	2.8	2.6
Depreciation and amortization	2.2	2.3	2.2
Finance costs	0.75	0.85	0.8
Effective tax rate on adjusted earnings (%)	24.0	26.0	28.0
Capital expenditures [3]	2.2	2.3	2.7

1 See the "Forward-Looking Statements" section.
2 Manufactured product only.
3 Comprised of sustaining capital expenditures, investing capital expenditures and mine development and pre-stripping capital expenditures which are supplementary financial measures. See the "Other Financial Measures" section.

Manufactured sales volume guidance

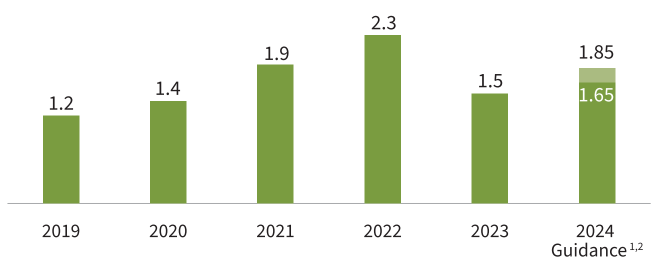
(millions of tonnes)



1 Guidance provided in our news release dated February 21, 2024.
2 See the "Forward-Looking Statements" section.

Retail adjusted EBITDA guidance

(US$ billions)



1 Guidance provided in our news release dated February 21, 2024.
2 See the "Forward-Looking Statements" section.

2024 Sensitivities

2024 Annual Sensitivities [1]	**Effect on**	
(millions of US dollars, except EPS amounts)	**Adjusted EBITDA**	**Adjusted EPS[4]**
$25/tonne change in net realized potash selling prices	± 270	± 0.40
$25/tonne change in net realized ammonia selling prices [2]	± 40	± 0.05
$25/tonne change in net realized urea and ESN® selling prices	± 80	± 0.10
$25/tonne change in net realized solutions, nitrates and sulfates selling prices	± 130	± 0.20
$1/MMBtu change in NYMEX natural gas price [3]	± 190	± 0.30

1 See the "Forward-Looking Statements" section.
2 Includes related impact on natural gas costs in Trinidad, which is linked to benchmark ammonia pricing.
3 Nitrogen related impact.
4 Assumes 496 million shares outstanding for all earnings per share ("EPS") sensitivities.

Annual financial information

(millions of US dollars, except as otherwise noted)	2023	2022	2021
Sales	29,056	37,884	27,712
Net earnings	1,282	7,687	3,179
Basic net earnings per share (US dollars)	2.53	14.22	5.53
Diluted net earnings per share (US dollars)	2.53	14.18	5.52
Total assets	52,749	54,586	49,954
Total non-current financial liabilities	9,912	8,939	8,455
Dividends declared per share (US dollars)	2.12	1.92	1.84

	2023 vs 2022	2022 vs 2021
Sales	Sales decreased primarily due to lower net realized selling prices compared to the historically strong prices in 2022, partially offset by higher sales volumes for crop nutrients, potash and nitrogen.	Sales increased primarily due to higher net realized selling prices from global supply uncertainties across our nutrient segments, partially offset by lower sales volumes. Strong Retail performance due to higher selling prices and increased sales of proprietary products, which more than offset a reduction in crop nutrients sales volumes from a delayed North American planting season and earlier engagement in the prior year in a rising price environment.
Net earnings and earnings per share	Net earnings and earnings per share decreased primarily due to lower net realized selling prices across our nutrient segments due to a decline in benchmark prices. In 2023, we recorded $774 million non-cash impairments of our Retail – South America assets, Phosphate White Springs and Nitrogen Trinidad property, plant and equipment compared to non-cash impairment reversals of $780 million of Phosphate assets recorded in 2022.	Net earnings and earnings per share increased due to historically strong net realized selling prices across our nutrient segments and strong Retail performance supported by the strength of agriculture fundamentals. In 2022, we recorded non-cash impairment reversals of our Phosphate Aurora and White Springs property, plant and equipment.
Assets and non-current financial liabilities	Total assets decreased approximately 3 percent from 2022 primarily due to lower receivables and inventories as we collected and sold through our higher-valued receivables and inventories from historically strong prices in 2022 and $774 million of non-cash impairments (as described above). This is partially offset by higher capital spending on property, plant and equipment. Non-current financial liabilities increased due to the higher long-term debt from the issuance of new senior notes.	Total assets increased approximately 10 percent from 2021. Our working capital assets increased from higher-valued receivables and inventories along with acquisition impacts. Property, plant and equipment increased primarily due to non-cash impairment reversals in the Phosphate segment. Non-current financial liabilities increased due to the higher long-term debt from the issuance of new senior notes.
Dividends declared per share	Dividends declared per share increased as we declared a quarterly dividend per share of $0.53 in 2023 compared to $0.48 in 2022.	Dividends declared per share increased as we declared a quarterly dividend per share of $0.48 in 2022 compared to $0.46 in 2021.

Financial condition review

Balance sheet analysis

(millions of US dollars, except as otherwise noted)	As at December 31, 2023	As at December 31, 2022	$ Change	% Change
Assets				
Receivables	5,398	6,194	(796)	(13)
Inventories	6,336	7,632	(1,296)	(17)
Property, plant and equipment	22,461	21,767	694	3
Goodwill	12,114	12,368	(254)	(2)
Liabilities and equity				
Short-term debt	1,815	2,142	(327)	(15)
Payables and accrued charges	9,467	11,291	(1,824)	(16)
Long-term debt	8,913	8,040	873	11
Share capital	13,838	14,172	(334)	(2)
Retained earnings	11,531	11,928	(397)	(3)

Assets

Receivables decreased due to lower selling prices across all of our operating segments compared to a historically strong period in 2022. These were partially offset by a strategic extension of credit terms to our Retail customers resulting in increased usage of Nutrien Financial programs.

Inventories decreased across all operating segments as we sold through our higher-cost inventories on hand as related benchmark prices decreased and from lower input costs including royalties, natural gas and sulfur. In 2022, we also strategically procured certain products at larger quantities in anticipation of supply chain challenges.

Property, plant and equipment increased from capital expenditures related to our Potash and Nitrogen capital projects and turnarounds to maintain safe and reliable operations. This is partially offset by non-cash impairments on our Phosphate White Springs and Nitrogen Trinidad property, plant and equipment of $309 million.

Goodwill decreased due to the recognition of a non-cash impairment of $422 million related to our Retail - South America assets in 2023.

Liabilities

Short-term debt decreased due to lower drawdowns on our credit facilities based on our working capital requirements.

Payables and accrued charges decreased due to lower accrual of income tax in 2023 compared to 2022, when we had historically strong earnings. Certain costs including products for resale, natural gas and sulfur input costs, and expenses tied to selling prices, such as provincial mining taxes also decreased. Payables also decreased from lower customer prepayments as a result of the lower commodity price environment and lower accruals for payroll expenses.

Long-term debt increased due to the issuance of $1.5 billion of senior notes in 2023, which exceeded the repayment of $500 million in senior notes upon maturity in the same period.

Shareholders' equity

Share capital decreased primarily from shares repurchased under our normal course issuer bid program.

Retained earnings decreased as dividends declared and share repurchases exceeded net earnings.

We do not hold material cash and cash equivalents in currencies other than the US dollar and Canadian dollar. As at December 31, 2023, we held approximately $243 million US dollar equivalent in other jurisdictions outside the US and Canada. We do not depend on repatriation of cash from our foreign subsidiaries to meet our liquidity and capital resource needs in North America.

Liquidity and capital resources

Sources and uses of liquidity

Liquidity risk arises from our general funding needs and in the management of our assets, liabilities and capital structure. We manage liquidity risk to maintain sufficient liquid financial resources to fund our financial position and meet our commitments and obligations in a cost-effective manner. Our 2023 significant liquidity sources are listed below along with our expected ongoing primary uses of liquidity:

Primary uses of liquidity

- inventory purchases and production
- operational expenses
- seasonal working capital requirements
- capital expenditures to sustain and grow our safe, reliable and cost-efficient operations
- business acquisitions
- shareholder returns through dividends and share repurchases
- principal payments of debt securities

Primary sources of liquidity

- cash from operations (including customer prepayments)
- commercial paper issuances
- increase of credit facility limits and drawdowns
- debt capital markets

We believe that our internally generated cash flow, supplemented by available borrowings under new or existing financing sources, if necessary, will be sufficient to meet our anticipated capital expenditures, planned growth and development activities, and other cash requirements for the foreseeable future. We do not reasonably expect any presently known trend or uncertainty to affect our ability to access our historical sources of liquidity.

Cash requirements

The following aggregated information about our contractual obligations and other commitments summarizes our liquidity and capital resource requirements as at December 31, 2023. Commitments reflect the estimated cash outflows for these obligations.

		Payments due by period				
(millions of US dollars)	Consolidated financial statements note reference	Total	Within 1 year	1 to 3 years	3 to 5 years	Over 5 years
Long-term debt	Notes 18, 26	9,214	512	1,528	870	6,304
Estimated interest payments on long-term debt	Note 26	6,125	454	796	686	4,189
Lease liabilities	Notes 19, 26	1,326	327	427	189	383
Estimated interest payments on lease liabilities	Note 26	199	41	57	33	68
Purchase commitments	Note 26	1,350	938	249	57	106
Capital commitments	Note 26	172	153	19	–	–
Other commitments	Note 26	715	188	221	149	157
Derivatives	Note 10	16	16	–	–	–
Asset retirement obligations and accrued environmental costs	Note 22	5,029	150	214	140	4,525
Total		24,146	2,779	3,511	2,124	15,732

The information presented in the table above does not include planned (but not legally committed) capital expenditures, business acquisitions or shareholder returns including share repurchases and dividends.

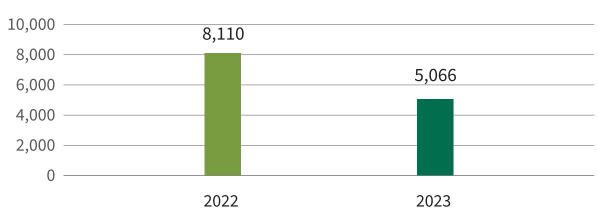
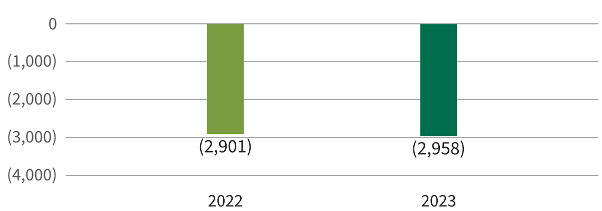
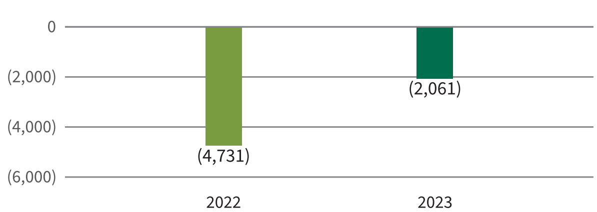
We incurred $50 million of capital expenditures related to the completion of our GHG Phase 1 abatement program since 2021. We originally anticipated investing more than $500 million to achieve at least a 30 percent reduction in GHG emissions (Scope 1 and 2) per tonne of our products produced, from a baseline year of 2018, by 2030. We continue to evaluate our strategic emissions abatement projects, including for technical and economic feasibility, as well as estimates on our expected capital expenditures to achieve our 2030 emissions intensity reduction target.

For information on income taxes and pension and other post-retirement benefits funding, refer to Note 8 and Note 21, respectively, to the consolidated financial statements. Future cash requirements are subject to changes in regulations, actuarial assumptions and our expected operating results.

On February 21, 2024, our Board of Directors approved a share repurchase program of up to a maximum of 24,728,159, representing 5 percent of Nutrien's outstanding common shares. The 2024 normal course issuer bid, which is subject to acceptance by the Toronto Stock Exchange, will commence on March 1, 2024. The share repurchase program will expire on the earlier of February 28, 2025, the date on which we have acquired the maximum number of common shares allowable or the date we determine not to make any further repurchases.

On February 21, 2024, our Board of Directors declared and increased our quarterly dividend to $0.54 per share payable on April 11, 2024, to shareholders of record on March 28, 2024. The total estimated dividend to be paid is $265 million.

Sources and uses of cash

Cash provided by operating activities	**Cash provided by operating activities** ($ millions)  Source: Nutrien	– Lower cash provided by operating activities from lower net realized selling prices across all segments compared to the historically strong benchmark prices in 2022.
Cash used in investing activities	**Cash used in investing activities** ($ millions)  Source: Nutrien	– Higher cash used in investing activities due to higher turnaround activities and investing capital expenditures as we completed our committed projects prior to our strategic actions to reduce capital spending.
Cash used in financing activities	**Cash used in financing activities** ($ millions)  Source: Nutrien	– Lower cash used in financing activities due to decreased share repurchases in 2023. We also had lower proceeds from our short-term and long-term debt in 2023 compared to 2022 by $500 million.

Capital structure and management

We manage our capital structure with a focus on maintaining a strong balance sheet, enabling a strong investment-grade credit rating.

Principal debt instruments

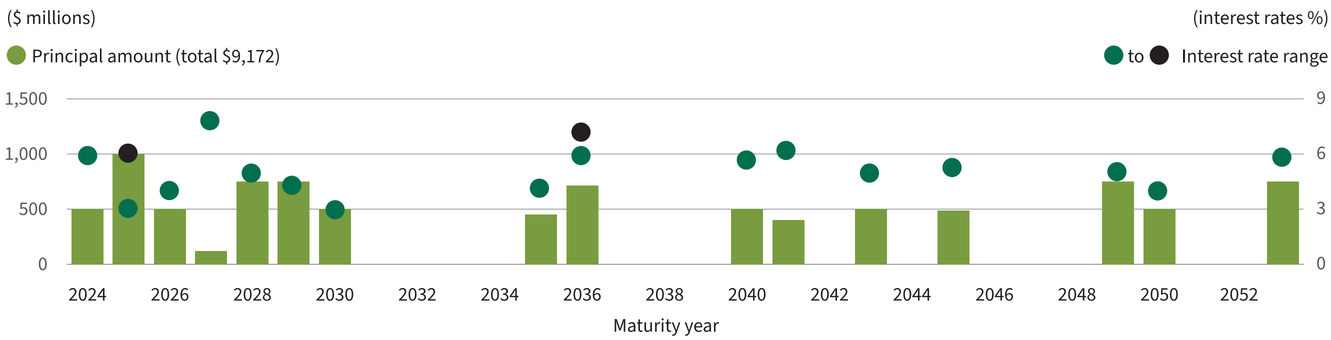
We use a combination of cash provided by operating activities and short-term and long-term debt to finance our operations.

Senior notes and debentures

As at December 31, 2023, our long-term debt consisted primarily of senior notes and debentures with the following maturities and interest rates:

Senior notes and debentures maturities and rates

As at December 31, 2023



Source: Nutrien

	Rate of interest (%)	Maturity	Amount
	Twelve Months Ended December 31		
Senior notes repaid 2023	1.9	May 13, 2023	500
Senior notes issued 2023	4.9	March 27, 2028	750
Senior notes issued 2023	5.8	March 27, 2053	750
			1,500

The senior notes issued in the twelve months ended December 31, 2023, are unsecured, rank equally with our existing unsecured debt, and have no sinking fund requirements prior to maturity. Each series is redeemable and has various provisions for redemption prior to maturity, at our option, at specified prices.

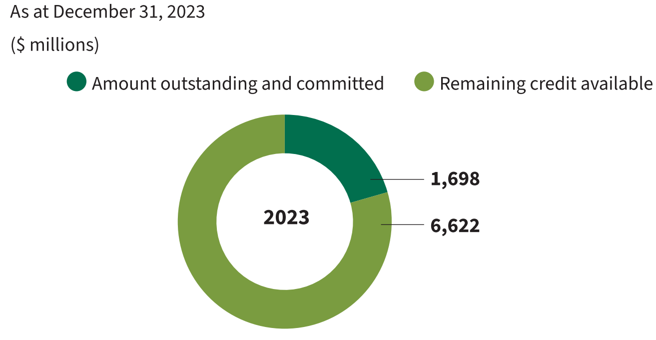
Credit facilities and other debt

We have several available credit facilities in the jurisdictions where we operate. We have a commercial paper program, which is limited to the undrawn amount under our $4,500 million unsecured revolving term credit facility and excess cash invested in highly liquid securities. As at December 31, 2023, we had a $1,175 million outstanding balance in commercial paper.

As at December 31, 2023, $252 million in letters of credit were outstanding and committed, with $203 million of remaining credit available under our dedicated letter of credit facilities.

Credit facilities

As at December 31, 2023



Source: Nutrien

Lease obligations

We also had lease obligations totaling $1,326 million (including current portion) with a weighted average effective interest rate of 4.3 percent as at December 31, 2023.

Debt covenants

Our credit facilities have financial tests and other covenants with which we must comply with at each quarter-end. Non-compliance with any such covenants could result in accelerated payment of amounts borrowed and termination of lenders' further funding obligations under the credit facilities. We were in compliance with all such covenants as at December 31, 2023.

The table below summarizes the limit and result of our key financial covenant:

As at December 31	Limit	2023
Debt to capital ratio [1]	0.65 : 1.00	0.33 : 1.00

1 Refer to Note 24 to the consolidated financial statements for the detailed calculation.

Credit ratings

Our ability to access reasonably priced debt in the capital markets depends, in part, on the quality of our credit ratings. We continue to maintain investment-grade credit ratings for our long-term debt. A downgrade of the credit rating of our long-term debt could increase the interest rates applicable to borrowings under our credit facilities.

Commercial paper markets are normally a source of same-day cash for us. Our access to the US commercial paper market primarily depends on maintaining our current short-term credit ratings as well as general conditions in the money markets.

	Long-term debt rating (outlook)		Short-term debt rating	
As at December 31	2023	2022	2023	2022
Moody's	Baa2 (stable)	Baa2 (stable)	P-2	P-2
S&P	BBB (stable)	BBB (positive)	A-2	A-2

A credit rating is not a recommendation to buy, sell or hold securities. Such ratings may be subject to revision or withdrawal at any time by the respective credit rating agency and each rating should be evaluated independently of any other rating.

S&P's stable outlook on Nutrien's credit ratings means that the ratings are not likely to change (generally up to two years).

Outstanding share data

	February 22, 2024
Common shares	**494,563,180**
Options to purchase common shares	**3,214,971**

For more information on our capital structure and management, see Note 24 to the consolidated financial statements.

Other financial information

Nature of financial information and consolidated financial statements note reference	Description
Off-balance sheet arrangements (Notes 10, 11, 22, 27 and 29)	Principal off-balance sheet activities primarily include: – Agreement to reimburse losses of Canpotex. – Issuance of guarantee contracts. – An agency arrangement with a financial institution in relation to certain customer loans. – Certain non-financial derivatives that were entered into and continued to be held for the purpose of the receipt or delivery of a non-financial item, such as grain or natural gas, in accordance with expected purchase, sale or usage requirements. Other derivatives are included on our balance sheet at fair value. We do not reasonably expect any presently known trend or uncertainty to affect our ability to continue using these arrangements, except as indicated above.
Related party transactions (Note 28)	Our most significant related party is Canpotex, which provides us with low-cost marketing and logistics for the offshore potash markets that we serve.
Financial instruments and other instruments (Note 10)	Our financial instruments are subject to various risks such as credit, liquidity and market risks. As discussed in the “Governance” section, our ELT is responsible for ensuring our principal risks, including financial risks, are being appropriately identified, assessed and addressed.

Critical accounting estimates

We prepare our consolidated financial statements in accordance with IFRS, which requires us to make judgments, assumptions and estimates in applying accounting policies. Critical accounting estimates are those which are highly uncertain at the time they are made or where different estimates would be reasonably likely to have a material impact on our financial condition or results of operations. We have discussed the development, selection and application of our key accounting policies, and the critical accounting estimates and assumptions they involve, with the Audit Committee of the Board.

Refer to the notes to the consolidated financial statements for additional information on the following critical accounting estimates including methodology used for calculating our estimates (when applicable), key assumptions used, and factors considered in our estimates and judgments.

Consolidated financial statements note reference	Critical accounting estimate description
Note 13 and Note 30	**Long-lived asset impairments and reversals**

We review, at each reporting period, for conditions to determine whether there is any indication that an impairment exists that could potentially impact the carrying amount of our long-lived assets to be held and used. When such indicators exist, impairment testing is performed. We review, at each reporting period, for possible reversal of the impairment for non-financial assets, other than goodwill.

In 2023, we identified an impairment trigger for our Phosphate cash generating units ("CGUs"), White Springs and Aurora, primarily as a result of the decrease in our forecasted phosphate margins. As a result of the impairment analysis, we recorded a non-cash impairment of property, plant and equipment amounting to $233 million at our White Springs CGU as the recoverable amount was less than its carrying value. The White Springs CGU has a shorter expected mine life and is therefore more sensitive to changes in short- and medium-term forecasted phosphate margins. We determined there was no impairment for our Aurora CGU.

The White Springs CGU and Aurora CGU had recoverable amounts of $504 million and $2,000 million, respectively. The following table highlights sensitivities to the recoverable amounts which could result in additional impairment losses or reversals of the previously recorded losses (relating to the White Springs CGU). The sensitivities have been calculated independently of changes in other key variables. Dollar amounts are in millions, except as otherwise noted.

		Change to recoverable amount ($)	
Key assumptions as at June 30, 2023	**Change in assumption**	**White Springs**	**Aurora**
Long-term growth rate (%)	+/-1.0 percent	n/a	+/-110
Pre-tax discount rate (%)	+/-1.0 percent	-/+20	n/a
Post-tax discount rate (%)	+/-1.0 percent	n/a	-/+190
Forecasted EBITDA over forecast period ($)	+/-5.0 percent	+/-40	+/-220

In 2023, we identified an impairment trigger for our Trinidad CGU, part of our Nitrogen segment, and recognized a $76 million non-cash impairment to property, plant and equipment, due to a new natural gas contract and the resulting outlook for higher expected natural gas costs and constrained near-term availability. We expect improved natural gas availability in Trinidad as the development of additional natural gas fields is anticipated to add new natural gas supply starting in 2026.

The Trinidad CGU had a recoverable amount of $676 million. The following table highlights sensitivities to the recoverable amount of our Trinidad CGU, which could result in additional impairment losses or reversals of the previously recorded losses. The sensitivities have been calculated independently of changes in other key variables. Dollar amounts are in millions, except as otherwise noted.

Key assumptions as at December 31, 2023	Change in assumption	Change to recoverable amount ($)
Long-term growth rate (%)	+/-1.0 percent	+/-55
Post-tax discount rate (%)	+/-1.0 percent	-/+95
Forecasted EBITDA over forecast period ($)	+/-5.0 percent	+/-100

Financial statement reference	Critical accounting estimate description
Note 14 and Note 30	**Goodwill impairment indicators**

We test our operating segments that have goodwill allocated to them when events or circumstances indicate that there could be an impairment, or at least annually on October 1. The key assumptions with the greatest influence on the calculation of the recoverable amounts are the discount rates, terminal growth rates and forecasted EBITDA. The key forecast assumptions were based on historical data and our estimates of future results from internal sources considering industry and market information. Key assumptions in our testing models may change, and changes that could reasonably be expected to occur may cause impairment. Such change in assumptions could be driven by global supply and demand, other market factors, changes in regulations, and other future events outside our control.

Recent acquisitions in Brazil resulted in goodwill being recognized for our Retail – South America group of CGUs. Goodwill is more susceptible to impairment risk if business operating results or economic conditions deteriorate and we anticipate not meeting our forecasts. In 2023, we revised our forecasted EBITDA for the Retail – South America group of CGUs, which triggered an impairment analysis. Due to the impact of crop input price volatility, more moderate long-term growth assumptions and higher interest rates, we lowered our product margin expectations and deferred certain of our planned strategic investments. As a result, this reduced our forecasted EBITDA and growth. As at June 30, 2023, the Retail – South America group of CGUs recoverable amount was lower than its carrying amount. As a result, we fully impaired goodwill of $422 million and recorded a $43 million impairment of intangible assets for a total of $465 million for the Retail – South America group of CGUs.

The following table highlights sensitivities to the recoverable amount which could have resulted in additional impairment against the carrying amount of intangible assets and property, plant and equipment. The sensitivities have been calculated independently of changes in other key variables. Dollar amounts are in millions, except as otherwise noted.

Key assumptions as at June 30, 2023	Change in key assumption	Decrease to recoverable amount ($)
Terminal growth rate (%)	-1.0 percent	50
Discount rate (%)	+1.0 percent	120
Forecasted EBITDA over forecast period ($)	-5.0 percent	100

The Retail – North America group of CGUs has $6,981 million in associated goodwill and at the annual testing date of October 1, 2023, the recoverable amount did not substantially exceed its carrying amount. The Retail – North America group of CGUs recoverable amount exceeds its carrying amount by $570 million. The following table indicates the percentage by which key assumptions would need to change individually for the estimated recoverable amount to be equal to the carrying amount. Dollar amounts are in millions, except as otherwise noted.

2023 Annual impairment testing	Key assumption used in impairment model	Change required for carrying amount to equal recoverable amount
Terminal growth rate (%)	2.5	0.4 percent decrease
Discount rate (%)	8.6	0.2 percent increase
Forecasted EBITDA over forecast period ($)	8,040	3.0 percent decrease

Note 22 and Note 30	**Asset retirement obligations ("AROs") and accrued environmental costs ("ERLs") – measurement**

AROs and ERLs have a high degree of estimation uncertainty for future costs and estimated remediation timelines. The Potash and Phosphate segments have AROs and ERLs associated with their mining operations while the Corporate and Others segment has these liabilities associated with non-operational mines.

For the Nitrogen segment, there are no significant AROs recorded as there is no reasonable basis for estimating a date or range of dates of cessation of operations. We considered the historical performance of our facilities as well as our planned maintenance, major upgrades and replacements, which can extend the useful lives of our facilities indefinitely.

Quarterly results

(millions of US dollars, except as otherwise noted)	2023				2022			
	Q4	Q3	Q2	Q1	Q4	Q3	Q2	Q1
Sales	5,664	5,631	11,654	6,107	7,533	8,188	14,506	7,657
Net earnings	176	82	448	576	1,118	1,583	3,601	1,385
Net earnings attributable to equity holders of Nutrien	172	75	440	571	1,112	1,577	3,593	1,378
Net earnings per share attributable to equity holders of Nutrien								
Basic	0.35	0.15	0.89	1.14	2.15	2.95	6.53	2.49
Diluted	0.35	0.15	0.89	1.14	2.15	2.94	6.51	2.49

Seasonality in our business results from increased demand for products during planting season. Crop input sales are generally higher in spring and fall application seasons. Crop input inventories are normally accumulated leading up to each application season. The results of this seasonality have a corresponding effect on receivables from customers and rebates receivables, inventories, prepaid expenses and other current assets, and trade payables. Our short-term debt also fluctuates during the year to meet working capital needs. Our cash collections generally occur after the application season is complete, while customer prepayments made to us are typically concentrated in December and January and inventory prepayments paid to our vendors are typically concentrated in the period from November to January. Feed and industrial sales are more evenly distributed throughout the year.

Our earnings are significantly affected by fertilizer benchmark prices, which have been volatile over the last two years and are affected by demand-supply conditions, grower affordability and weather.

Other material transactions or events that impacted our quarterly results included:

Quarter	Transaction or event
2023 Q2	$698 million non-cash impairment of assets comprising a $233 million non-cash impairment of our Phosphate White Springs property, plant and equipment due to a decrease in our forecasted phosphate margins and a $465 million non-cash impairment of our Retail – South America assets primarily related to goodwill mainly due to the impact of crop input price volatility, more moderate long-term growth assumptions and higher interest rates which lowered our forecasted earnings.
2022 Q3	$330 million reversal of non-cash impairment of our Phosphate White Springs property, plant and equipment related to higher forecasted global prices and a more favorable outlook for phosphate margins.
2022 Q2	$450 million reversal of non-cash impairment of our Phosphate Aurora property, plant and equipment related to higher forecasted global prices and a more favorable outlook for phosphate margins.

Fourth quarter financial performance

(millions of US dollars, except as otherwise noted)	Sales			Gross margin		
Three months ended December 31	2023	2022	% Change	2023	2022	% Change
Retail						
Crop nutrients	1,808	2,320	(22)	346	349	(1)
Crop protection products	960	981	(2)	333	413	(19)
Seed	202	251	(20)	36	46	(22)
Merchandise	251	264	(5)	41	41	–
Nutrien Financial	70	62	13	70	62	13
Services and other	236	237	–	188	194	(3)
Nutrien Financial elimination [1]	(25)	(28)	(11)	(25)	(28)	(11)
Total	3,502	4,087	(14)	989	1,077	(8)

1 Represents elimination for the interest and service fees charged by Nutrien Financial to Retail branches.

(US dollars, except as otherwise noted)	Manufactured product sales tonnes (thousands)			Manufactured product average per tonne		
Three months ended December 31	2023	2022	% Change	2023	2022	% Change
Potash						
North America	1,089	959	14	342	560	(39)
Offshore	2,214	1,659	33	182	506	(64)
Sales	3,303	2,618	26	235	526	(55)
Cost of goods sold				106	118	(10)
Gross margin				129	408	(68)
Nitrogen						
Ammonia	651	776	(16)	416	887	(53)
Urea and ESN® [1]	739	764	(3)	428	666	(36)
Solutions, nitrates and sulfates	1,344	1,056	27	215	368	(42)
Sales	2,734	2,596	5	321	611	(47)
Cost of goods sold [1]				218	343	(36)
Gross margin				103	268	(62)
Phosphate						
Fertilizer	579	391	48	557	700	(20)
Industrial and feed	174	140	24	860	1,107	(22)
Sales	753	531	42	627	807	(22)
Cost of goods sold				535	762	(30)
Gross margin				92	45	104

1 Certain immaterial 2022 figures have been reclassified.

	Three months ended December 31		
(millions of US dollars, except as otherwise noted)	2023	2022	% Change
Adjusted EBITDA			
Retail	229	391	(41)
Potash	463	958	(52)
Nitrogen	391	841	(54)
Phosphate	130	28	364
Corporate and others	(117)	(180)	(35)
Eliminations	(21)	57	n/m
Adjusted EBITDA[1]	1,075	2,095	(49)
Net earnings	176	1,118	(84)

1 This is a non-GAAP financial measure. See the "Non-GAAP Financial Measures" section for further information.

Highlights of our 2023 fourth quarter compared to the 2022 fourth quarter results were as follows:

	Q4 2023 vs Q4 2022
Retail	Gross margin decreased in 2023 primarily due to lower gross margin for crop protection products. Crop protection products sales were lower primarily due to decreased selling prices compared to the historically strong comparable period in 2022. This was partially offset by higher sales in North America as growers returned to more normalized buying behaviors. Crop nutrients sales and gross margin decreased due to lower selling prices across all regions compared to the strong comparable period in 2022. Sales volumes increased as growers returned to more normalized application rates to replenish nutrients in the soil. Seed sales and gross margin decreased due to lower soybean sales volumes and competitive market prices in Latin America.
Potash	Gross margin decreased due to lower net realized selling prices, which more than offset higher North American and Offshore sales volumes and lower royalties. Net realized selling price decreased compared to the historically strong period in 2022, due to a decline in benchmark prices and higher costs related to logistical challenges at Canpotex's West Coast port facilities. Sales volumes in North America were higher due to lower channel inventory and increased grower demand supported by an extended fall application window and improved affordability. Offshore sales volumes were driven by stronger demand in Brazil and China. Cost of goods sold per tonne decreased mainly due to lower royalties and reduced turnaround activity.
Nitrogen	Gross margin was lower due to lower net realized selling prices for all major nitrogen products, which more than offset lower natural gas costs and higher sales volumes. Net realized selling price was lower for all major nitrogen products primarily due to weaker benchmark prices resulting from lower energy prices in key nitrogen producing regions. Sales volumes were higher primarily due to higher UAN production and sales, partially offset by lower ammonia availability mainly due to unplanned production outages at our plants in Trinidad. Cost of goods sold per tonne decreased mainly due to lower natural gas costs. We recognized a $76 million non-cash impairment of our Trinidad property, plant and equipment due to a new natural gas contract and the resulting outlook for higher expected natural gas costs and constrained near-term availability. We expect improved natural gas availability in Trinidad as the development of additional gas fields is anticipated to add new supply starting in 2026.
Phosphate	Gross margin increased primarily due to lower sulfur and ammonia input costs, partially offset by lower net realized selling prices. Net realized selling price decreased primarily due to lower fertilizer net realized selling prices from weaker benchmark prices and lower industrial and feed net realized selling prices, which reflect the typical lag in price realizations relative to spot fertilizer prices. Sales volumes increased mostly due to higher phosphate fertilizer demand. Cost of goods sold per tonne decreased mainly due to lower ammonia and sulfur costs, partially offset by higher depreciation from reversal of non-cash impairments in 2022.
Other fourth quarter financial highlights	The Corporate and Others segment reflects $142 million of higher expenses for asset retirement obligations and accrued environmental costs related to our non-operating sites due to changes in closure cost estimates. Finance costs were higher primarily due to higher interest rates and higher average long-term debt balances. Income tax expense and effective tax rate reflect a $134 million income tax recovery due to changes to our tax declarations in Switzerland ("Swiss Tax Reform adjustment"). The fourth quarter 2023 effective tax rate also includes the impact of our losses in Retail – South America, wherein we did not recognize a corresponding deferred tax asset as it did not meet the accounting criteria for asset recognition.

Controls and procedures

Disclosure controls and procedures

We maintain disclosure controls and procedures designed to provide reasonable assurance that information required to be disclosed by Nutrien in its annual filings, interim filings (as these terms are defined in National Instrument 52-109 – *Certification of Disclosure in Issuers' Annual and Interim Filings* ("NI 52-109")), and other reports filed or submitted by us under securities legislation is recorded, processed, summarized and reported within the required time periods. Our Chief Executive Officer and Chief Financial Officer, after evaluating the effectiveness of our disclosure controls and procedures as of the end of the period covered by the annual filings, being December 31, 2023, have concluded that, as of such date, our disclosure controls and procedures were effective in providing reasonable assurance that information required to be disclosed by Nutrien in its annual filings, interim filings, or other reports filed or submitted by it under securities legislation is (a) recorded, processed, summarized and reported within the time periods specified in the securities legislation, and (b) accumulated and communicated to management, including our Chief Executive Officer and Chief Financial Officer, as appropriate, to allow timely decisions regarding required disclosure.

There are inherent limitations to the effectiveness of any system of disclosure controls and procedures, including the possibility of human error and the circumvention or overriding of the controls and procedures. Accordingly, even effective disclosure controls and procedures can only provide reasonable assurance of achieving their control objectives.

Internal control over financial reporting

Management is responsible for establishing and maintaining adequate internal control over financial reporting, as defined in Rules 13a-15(f) and 15d-15(f) under the Securities Exchange Act of 1934, as amended, and NI 52-109. Internal control over financial reporting is designed to provide reasonable assurance regarding the reliability of financial reporting and preparation of consolidated financial statements for external purposes in accordance with IFRS.

Under the supervision and with the participation of our management, including our Chief Executive Officer and Chief Financial Officer, we conducted an evaluation of the design and effectiveness of our internal control over financial reporting as of the end of the fiscal year covered by this report based on the framework issued by the Committee of Sponsoring Organizations of the Treadway Commission in Internal Control – Integrated Framework (2013). Based on this evaluation, our Chief Executive Officer and Chief Financial Officer concluded that, as at December 31, 2023, Nutrien Ltd. did maintain effective internal control over financial reporting. There have been no changes that have materially affected, or are reasonably likely to materially affect, our internal control over financial reporting.

The effectiveness of the Company's internal control over financial reporting as at December 31, 2023 was audited by KPMG LLP, as reflected in their report, which is included in this 2023 Annual Report.

Forward-looking statements

Certain statements and other information included in this document, including within the “2024 Guidance” section and the “Market outlook” sections for each segment, constitute “forward-looking information” or “forward-looking statements” (collectively, “forward-looking statements”) under applicable securities laws (such statements are often accompanied by words such as “anticipate”, “forecast”, “expect”, “believe”, “may”, “will”, “should”, “estimate”, “project”, “intend” or other similar words). All statements in this document, other than those relating to historical information or current conditions, are forward-looking statements, including, but not limited to:

Nutrien’s business strategies, plans, prospects and opportunities; Nutrien’s 2024 annual guidance, including expectations regarding our Retail adjusted EBITDA, Potash sales volumes, Nitrogen sales volumes, Phosphate sales volumes, depreciation and amortization, finance costs, effective tax rate on adjusted earnings and capital expenditures; our projections to generate strong cash from operations and expectations regarding our capital allocation intentions and strategies, including with respect to expansion of our portfolio of advanced nutrition products and overall growth of the Retail platform and network optimization initiatives; our ability to advance strategic initiatives and high value growth investments, including expectations regarding our ability to serve growers, maintain a low-cost position of fertilizer production assets and increase free cash flow; capital spending expectations for 2024 and beyond, including spending related to advancement of proprietary products, network optimization and digital capabilities in Retail, automation in Potash mining, and brownfield expansions in Nitrogen; expectations regarding our ability to generate free cash flow and return capital to our shareholders, including our expectations regarding stable and growing dividends; our ability to reduce our GHG emissions, and the initiatives in connection therewith, including the expected impacts in connection with the installment of our final N_2O abatement project; expectations and forecasts relating to our Aurora and White Springs CGUs and the reversals and impairments (as applicable) associated therewith; our ability to advance strategic growth initiatives; the expected impacts and timing of new supply from additional gas fields in Trinidad; the resulting outlook of higher expected gas costs and lower near-term availability from the new natural gas contract related to our Trinidad property, plant and equipment in our Nitrogen segment and the impairments associated therewith; capital spending expectations for 2024 and beyond, including our intention to reduce planned capital expenditures in 2024 and our goal to continuously improve in our initiatives and make selective and strategic investments; expectations regarding Retail inventory levels in North America; expectations regarding performance of our operating segments in 2024, including increased fertilizer sales volumes and growth in Retail earnings; our operating segment market outlooks and our expectations for global market conditions and fundamentals in 2024 and beyond, including agriculture and crop nutrient markets and global energy supply, the anticipated supply and demand for our products and services, expected market, industry and growing conditions with respect to crop nutrient application rates, planted acres, grower crop investment, crop mix, including the need to replenish soil nutrient levels, production volumes and expenses, shipments, natural gas costs and availability, consumption, prices, operating rates, the impact of seasonality, import and export volumes, economic sanctions, inventories, crop development, natural gas curtailments in Trinidad and elsewhere, and global population growth expectations; the expected impact on nitrogen volume growth of completed brownfield expansions at our Geismar site and the anticipated effects of our UAN debottleneck projects; expectations concerning future product offerings; expectations regarding changes in the agriculture space, including continued farm consolidation in the US and other developed markets and the continued advancement and adoption of technology and digital innovations, including the use and anticipated effects of autonomous mining and reliability improvements, new crop input technologies, artificial technology, biostimulants, biological product technologies and advanced nutrition products, and agronomic capabilities; expectations regarding environmental compliance requirements and costs, including estimates of asset retirement obligations, federal and provincial carbon pricing, permits, approvals and site assessment and remediation costs; expectations regarding our sustainability initiatives and our proposed responses to climate change, including our GHG emissions reduction strategy and related programs and initiatives, our various sustainability performance goals, targets, costs, capital expenditures, commitments and aspirations as set out in our Feeding the Future Plan and the 2023 ESG Report; our evaluation of future opportunities with respect to the suspended Geismar clean ammonia project; the negotiation of sales and other contracts, including the expiry of existing contracts; initiatives to promote innovative, sustainable and productive agriculture; timing and impacts of plant turnarounds; acquisitions and divestitures and the anticipated benefits thereof; and expectations in connection with our ability to deliver long-term returns to shareholders.

These forward-looking statements are subject to a number of assumptions, risks and uncertainties, many of which are beyond our control, which could cause actual results to differ materially from such forward-looking statements. As such, undue reliance should not be placed on these forward-looking statements.

All of the forward-looking statements are qualified by the assumptions that are stated or inherent in such forward-looking statements, including the assumptions referred to below and elsewhere in this document. Although we believe that these assumptions are reasonable, having regard to our experience and our perception of historical trends, the assumptions set forth below are not exhaustive of the factors that may affect any of the forward-looking statements and the reader should not place undue reliance on these assumptions and such forward-looking statements. Current conditions, economic and otherwise, render assumptions, although reasonable when made, subject to greater uncertainty.

Mid-cycle scenarios are based on medium-term estimates for manufactured sales volumes and Retail adjusted EBITDA. Mid-cycle pricing assumptions are based on a ten-year historical average of fertilizer benchmark pricing from June 2013 to June 2023, plus approximately $50 per tonne. In respect of our mid-cycle scenario estimates, we have made assumptions with respect to, among other things: our expectations for global economic conditions including supply and demand for fertilizer, fertilizer and commodity prices and global potash volumes returning to historical trend line growth rates; our expectations for our logistics and production capacity; our expectations for Retail margin normalization; our ability to increase sales volumes as global demand grows; and our expectations for access to and availability of capital, foreign exchange, inflation and interest rates, costs and availability of labor and technology.

In respect of our GHG emissions reduction and other sustainability and climate-related initiatives and targets, we have made assumptions with respect to, among other things: that such target is achievable by deploying capital into N_2O abatement at our nitric acid production facilities, energy efficiency improvements, carbon capture, utilization and storage, use of natural gas to generate electricity and waste heat recovery; our ability to successfully deploy capital and pursue other operational measures, including the successful application to our current and future operations of existing and new technologies; the successful implementation by us of proposed or potential plans in respect thereof; projected capital investment levels, the flexibility of our capital spending plans and the associated sources of funding; our expectations for our production mix between nitrogen, phosphate and potash and grid decarbonization (including timing thereof); our ability to otherwise implement all

technology necessary to achieve our GHG emissions reduction and other sustainability and climate-related initiatives and targets; and the development, availability and performance of technology and technological innovations and associated expected future results. Additional key assumptions that have been made in relation to the operation of our business as currently planned and our ability to achieve our business objectives include, among other things, assumptions with respect to our ability to successfully implement our business strategies, growth and capital allocation investments and initiatives that we will conduct our operations and achieve results of operations as anticipated; our ability to successfully complete, integrate and realize the anticipated benefits of our already completed and future acquisitions and divestitures, and that we will be able to implement our standards, controls, procedures and policies in respect of any acquired businesses and realize the expected synergies on the anticipated timeline or at all; that future business, regulatory and industry conditions will be within the parameters expected by us, including with respect to prices, expenses, margins, demand, supply, product availability, shipments, consumption, weather conditions, including the current El Niño weather pattern, supplier agreements, product distribution agreements, availability, inventory levels, exports, crop development and cost of labor and interest, exchange and effective tax rates; assumptions with respect to global economic conditions and the accuracy of our market outlook expectations for 2024 and beyond; assumptions related to our assessment of recoverable amount estimates of our assets, including in relation to our Retail – South America group of CGUs goodwill and intangible asset impairments; assumptions related to the calculation of recoverable amount of our Aurora and White Springs CGUs, including internal sales and input price forecasts, discount rate, long-term growth rate and end of expected mine life; assumptions with respect to the benefits of the brownfield expansions at our Geismar site; assumptions related to the impairment of our Nitrogen and Phosphate property, plant and equipment; assumptions with respect to our intention to complete share repurchases under our normal course issuer bid programs, including TSX approval, the funding of such share repurchases, existing and future market conditions, including with respect to the price of our common shares, and compliance with respect to applicable limitations under securities laws and regulations and stock exchange policies; assumptions related to our ability to fund our dividends at the current level; our expectations regarding the impacts, direct and indirect, of certain geopolitical conflicts, including the war in Eastern Europe and the conflict in the Middle East on, among other things, global supply and demand, including for crop nutrients, energy and commodity prices, global interest rates, supply chains and the global macroeconomic environment, including inflation; assumptions regarding future markets for clean ammonia; the adequacy of our cash generated from operations and our ability to access our credit facilities or capital markets for additional sources of financing; our ability to identify suitable candidates for acquisitions and divestitures and negotiate acceptable terms; our ability to maintain investment grade ratings and achieve our performance targets; our ability to successfully negotiate sales and other contracts; and our ability to successfully implement new initiatives and programs. Key assumptions with respect to our 2030 commitment of a 30% reduction in GHG emissions (Scope 1 and 2) per tonne of our products produced, from a baseline year of 2018, include growth in potash production volumes, operating rates within expected parameters and grid decarbonization progressing on expected timelines.

Events or circumstances could cause actual results to differ materially from those in the forward-looking statements.

With respect to our GHG emissions reduction and other sustainability and climate-related initiatives and targets, such events or circumstances include, but are not limited to: our ability to deploy sufficient capital to fund the necessary expenditures to implement the necessary operational changes to achieve these initiatives and targets; our ability to implement requisite operational changes; our ability to implement some or all of the technology necessary to efficiently and effectively achieve expected future results, including in respect of such GHG emissions reduction target; the availability and commercial viability and scalability of emissions reduction strategies and related technology and products; and the development and execution of implementing strategies to meet such GHG emissions reduction target.

With respect to our business generally and our ability to meet other targets, commitments, goals, strategies and related milestones and schedules disclosed in this document, such events or circumstances include, but are not limited to: general global economic, market and business conditions; failure to achieve expected results of our business strategy, capital allocation initiatives or results of operations; failure to complete announced and future acquisitions or divestitures at all or on the expected terms and within the expected timeline; seasonality; climate change and weather conditions, including the current El Niño weather pattern, and impacts from regional flooding and/or drought conditions; failure to execute on our strategies related to sustainability matters or to achieve our GHG emission and other related expectations, targets, goals and commitments; crop planted acreage, yield and prices; the supply and demand and price levels for our products; governmental and regulatory requirements and actions by governmental authorities, including changes in government policy (including tariffs, trade restrictions and climate change initiatives), government ownership requirements, and changes in environmental, tax, antitrust, and other laws or regulations and the interpretation thereof; political or military risks, including civil unrest, actions by armed groups or conflict and malicious acts including terrorism and industrial espionage; our ability to access sufficient, cost-effective and timely transportation, distribution and storage of products; the occurrence of a major environmental or safety incident or becoming subject to legal or regulatory proceedings; innovation and cybersecurity risks related to our systems, including our costs of addressing or mitigating such risks; counterparty and sovereign risk; delays in completion of turnarounds at our major facilities or challenges related to our major facilities that are out of our control; interruptions of or constraints in availability of key inputs, including natural gas and sulfur; any significant impairment of the carrying amount of certain assets; the risk that rising interest rates and/or deteriorated business operating results may result in the further impairment of assets or goodwill attributed to certain CGUs; risks related to reputational loss; certain complications that may arise in our mining processes; the ability to attract, engage and retain skilled employees and strikes or other forms of work stoppages; geopolitical conflicts, including the war in Eastern Europe and the conflict in the Middle East, and their potential impact on, among other things, global market conditions and supply and demand, including for crop nutrients, energy and commodity prices, interest rates, supply chains and the global economy generally; our ability to execute on our strategies related to environmental, social and governance matters, and achieve expectations, targets and commitments; and other risk factors detailed from time to time in Nutrien reports filed with the Canadian securities regulators and the SEC in the US.

The purpose of our 2024 Retail adjusted EBITDA, depreciation and amortization, finance costs, effective tax rate on adjusted earnings and capital expenditures guidance ranges are to assist readers in understanding our expected and targeted financial results, and this information may not be appropriate for other purposes.

The forward-looking statements in this document are made as of the date hereof and Nutrien disclaims any intention or obligation to update or revise any forward-looking statements in this document as a result of new information or future events, except as may be required under applicable Canadian securities legislation or applicable US federal securities laws.

Appendix A – non-GAAP financial measures

We use both IFRS measures and certain non-GAAP financial measures to assess performance. Non-GAAP financial measures are financial measures disclosed by the Company that (a) depict historical or expected future financial performance, financial position or cash flow of the Company, (b) with respect to their composition, exclude amounts that are included in, or include amounts that are excluded from, the composition of the most directly comparable financial measure disclosed in the primary financial statements of the Company, (c) are not disclosed in the financial statements of the Company and (d) are not a ratio, fraction, percentage or similar representation. Non-GAAP ratios are financial measures disclosed by the Company that are in the form of a ratio, fraction, percentage or similar representation that has a non-GAAP financial measure as one or more of its components, and that are not disclosed in the financial statements of the Company.

These non-GAAP financial measures and non-GAAP ratios are not standardized financial measures under IFRS and, therefore, are unlikely to be comparable to similar financial measures presented by other companies. Management believes these non-GAAP financial measures and non-GAAP ratios provide transparent and useful supplemental information to help investors evaluate our financial performance, financial condition and liquidity using the same measures as management. These non-GAAP financial measures and non-GAAP ratios should not be considered as a substitute for, or superior to, measures of financial performance prepared in accordance with IFRS.

The following section outlines our non-GAAP financial measures and non-GAAP ratios, their compositions, and why management uses each measure. It also includes reconciliations to the most directly comparable IFRS measures. Except as otherwise described herein, our non-GAAP financial measures and non-GAAP ratios are calculated on a consistent basis from period to period and are adjusted for specific items in each period, as applicable. As additional non-recurring or unusual items arise in the future, we generally exclude these items in our calculations.

Adjusted EBITDA (consolidated)

Most directly comparable IFRS financial measure: Net earnings (loss).

Definition: Adjusted EBITDA is calculated as net earnings (loss) before finance costs, income taxes, depreciation and amortization, share-based compensation and certain foreign exchange gain/loss (net of related derivatives). We also adjust this measure for the following other income and expenses that are excluded when management evaluates the performance of our day-to-day operations: integration and restructuring related costs, impairment or reversal of impairment of assets, COVID-19 related expenses, gain or loss on disposal of certain businesses and investments, asset retirement obligations ("ARO") and accrued environmental costs ("ERL") related to our non-operating sites, and loss on remitting cash from certain foreign jurisdictions (e.g. Blue Chip Swaps). In 2023, we amended our calculation of adjusted EBITDA to adjust for the asset retirement obligations and accrued environmental costs related to our non-operating sites and the loss on remitting cash from certain foreign jurisdictions. We do not consider these to be part of our day-to-day operations. There were no similar income and expense in the comparative periods.

Why we use the measure and why it is useful to investors: It is not impacted by long-term investment and financing decisions, but rather focuses on the performance of our day-to-day operations. It provides a measure of our ability to service debt and to meet other payment obligations and as a component of employee remuneration calculations.

(millions of US dollars)	2023	2022
Net earnings	1,282	7,687
Finance costs	793	563
Income tax (recovery) expense	670	2,559
Depreciation and amortization	2,169	2,012
EBITDA [1]	4,914	12,821
Adjustments:		
Integration and restructuring related costs	49	46
Share-based compensation (recovery) expense	(14)	63
Impairment (reversal of impairment) of assets	774	(780)
ARO/ERL expense for non-operating sites	152	–
Foreign exchange loss, net of related derivatives	91	31
Loss on Blue Chip Swaps	92	–
Gain on disposal of investment	–	(19)
COVID-19 related expenses [2]	–	8
Adjusted EBITDA	6,058	12,170

1 EBITDA is calculated as net earnings before finance costs, income taxes, and depreciation and amortization.
2 COVID-19 related expenses primarily consist of increased cleaning and sanitization costs, the purchase of personal protective equipment, discretionary supplemental employee costs, and costs related to construction delays from access limitations and other government restrictions.

Adjusted net earnings and adjusted net earnings per share

Most directly comparable IFRS financial measure: Net earnings (loss) and diluted net earnings (loss) per share.

Definition: Adjusted net earnings and related per share information are calculated as net earnings (loss) before share-based compensation and certain foreign exchange gain/loss (net of related derivatives), net of tax. We also adjust this measure for the following other income and expenses (net of tax) that are excluded when management evaluates the performance of our day-to-day operations: certain integration and restructuring related costs, impairment or reversal of impairment of assets, COVID-19 related expenses (including those recorded under finance costs), gain or loss on disposal of certain businesses and investments, gain or loss on early extinguishment of debt or on settlement of derivatives due to discontinuance of hedge accounting, asset retirement obligations and accrued environmental costs related to our non-operating sites, loss on remitting cash from certain foreign jurisdictions (e.g. Blue Chip Swaps), change in recognition of tax losses and deductible temporary differences related to impairments and certain changes to tax declarations in Switzerland ("Swiss Tax Reform adjustment") resulting in an income tax recovery from the recognition of a deferred tax asset. In 2023, we amended our calculation of adjusted net earnings and adjusted net earnings per share to adjust for the asset retirement obligations and accrued environmental costs related to our non-operating sites, the loss on remitting cash from certain foreign jurisdictions, the change in recognition of Retail – South America tax losses and deductible temporary differences and the Swiss Tax Reform adjustment. We do not consider these to be part of our day-to-day operations. There were no similar income and expense in the comparative periods. We generally apply the annual forecasted effective tax rate to our adjustments during the year, and at year-end, we apply the actual effective tax rate. Prior to December 31, 2023, we applied a specific tax rate for material adjustments. Effective December 31, 2023, we applied a tax rate specific to each adjustment.

Why we use the measure and why it is useful to investors: Focuses on the performance of our day-to-day operations and is used as a component of employee remuneration calculations.

	2023			2022		
(millions of US dollars, except as otherwise noted)	Increases (decreases)	Post-tax	Per diluted share	Increases (decreases)	Post-tax	Per diluted share
Net earnings attributable to equity holders of Nutrien		1,258	2.53		7,660	14.18
Adjustments:						
Share-based compensation (recovery) expense	(14)	(11)	(0.02)	63	47	0.10
Foreign exchange loss, net of related derivatives	91	83	0.17	31	23	0.05
Integration and restructuring related costs	49	40	0.08	46	35	0.06
Impairment (reversal of impairment) of assets	774	702	1.42	(780)	(619)	(1.15)
ARO/ERL expense for non-operating sites	152	110	0.22	–	–	–
Loss on Blue Chip Swaps	92	92	0.18	–	–	–
Change in recognition of deferred tax assets	66	66	0.13	–	–	–
Swiss Tax Reform adjustment	(134)	(134)	(0.27)	–	–	–
COVID-19 related expenses	–	–	–	8	6	0.01
Gain on disposal of investment	–	–	–	(19)	(14)	(0.03)
Gain on settlement of discontinued hedge accounting derivative	–	–	–	(18)	(14)	(0.03)
Adjusted net earnings		2,206	4.44		7,124	13.19

Gross margin excluding depreciation and amortization per tonne – manufactured

Most directly comparable IFRS financial measure: Gross margin.

Definition: Gross margin per tonne less depreciation and amortization per tonne for manufactured products. Reconciliations are provided in the "Results – Operating Segment Performance" section.

Why we use the measure and why it is useful to investors: Focuses on the performance of our day-to-day operations, which excludes the effects of items that primarily reflect the impact of long-term investment and financing decisions.

Potash controllable cash cost of product manufactured ("COPM") per tonne

Most directly comparable IFRS financial measure: Cost of goods sold ("COGS") for the Potash segment.

Definition: Total Potash COGS excluding depreciation and amortization expense included in COPM, royalties, natural gas costs and carbon taxes, change in inventory, and other adjustments, divided by potash production tonnes.

Why we use the measure and why it is useful to investors: To assess operational performance. Potash controllable cash COPM excludes the effects of production from other periods and the impacts of our long-term investment decisions, supporting a focus on the performance of our day-to-day operations. Potash controllable cash COPM also excludes royalties and natural gas costs and carbon taxes, which management does not consider controllable, as they are primarily driven by regulatory and market conditions.

(millions of US dollars, except as otherwise noted)	2023	2022
Total COGS – Potash	1,396	1,400
Change in inventory	(40)	58
Other adjustments [1]	(26)	(41)
COPM	1,330	1,417
Depreciation and amortization in COPM	(427)	(406)
Royalties in COPM	(100)	(190)
Natural gas costs and carbon taxes in COPM	(46)	(62)
Controllable cash COPM	757	759
Production tonnes (tonnes – thousands)	12,998	13,007
Potash controllable cash COPM per tonne	58	58

1 Other adjustments include unallocated production overhead that is recognized as part of cost of goods sold but is not included in the measurement of inventory and changes in inventory balances.

Ammonia controllable cash COPM per tonne

Most directly comparable IFRS financial measure: Total manufactured COGS for the Nitrogen segment.

Definition: Total Nitrogen COGS excluding depreciation and amortization expense included in COGS, cash COGS for products other than ammonia, other adjustments, and natural gas and steam costs, divided by net ammonia production tonnes.

Why we use the measure and why it is useful to investors: To assess operational performance. Ammonia controllable cash COPM excludes the effects of production from other periods, the costs of natural gas and steam, and long-term investment decisions, supporting a focus on the performance of our day-to-day operations.

(millions of US dollars, except as otherwise noted)	2023	2022
Total manufactured COGS – Nitrogen [1]	2,435	3,370
Total other COGS – Nitrogen [1]	393	882
Total COGS – Nitrogen	2,828	4,252
Depreciation and amortization in COGS	(474)	(465)
Cash COGS for products other than ammonia	(1,693)	(2,560)
Ammonia		
Total cash COGS before other adjustments	661	1,227
Other adjustments [2]	(222)	(210)
Total cash COPM	439	1,017
Natural gas and steam costs in COPM	(304)	(855)
Controllable cash COPM	135	162
Production tonnes (net tonnes [3] – thousands)	2,276	2,754
Ammonia controllable cash COPM per tonne	60	59

1 Certain immaterial 2022 figures have been reclassified.
2 Other adjustments include unallocated production overhead that is recognized as part of cost of goods sold but is not included in the measurement of inventory and changes in inventory balances.
3 Ammonia tonnes available for sale, as not upgraded to other nitrogen products.

Retail adjusted average working capital to sales and retail adjusted average working capital to sales excluding Nutrien Financial

Definition: Retail adjusted average working capital divided by Retail adjusted sales for the last four rolling quarters. We exclude in our calculations the sales and working capital of certain acquisitions during the first year following the acquisition. We also look at this metric excluding Nutrien Financial revenue and working capital.

Why we use the measure and why it is useful to investors: To evaluate operational efficiency. A lower or higher percentage represents increased or decreased efficiency, respectively. The metric excluding Nutrien Financial shows the impact that the working capital of Nutrien Financial has on the ratio.

(millions of US dollars, except as otherwise noted)	2023	2022
Average current assets	11,470	11,952
Average current liabilities	7,666	8,249
Average working capital	3,804	3,703
Average working capital from certain recent acquisitions	–	–
Adjusted average working capital	3,804	3,703
Average Nutrien Financial working capital	(3,561)	(3,311)
Adjusted average working capital excluding Nutrien Financial	243	392
Sales	19,542	21,350
Sales from certain recent acquisitions	–	–
Adjusted sales	19,542	21,350
Nutrien Financial revenue	(322)	(267)
Adjusted sales excluding Nutrien Financial	19,220	21,083
Adjusted average working capital to sales (%)	19	17
Adjusted average working capital to sales excluding Nutrien Financial (%)	1	2

Nutrien Financial adjusted net interest margin

Definition: Nutrien Financial revenue less deemed interest expense divided by average Nutrien Financial net receivables outstanding for the last four rolling quarters.

Why we use the measure and why it is useful to investors: Used by credit rating agencies and others to evaluate the financial performance of Nutrien Financial.

(millions of US dollars, except as otherwise noted)	2023	2022
Nutrien Financial revenue	322	267
Deemed interest expense [1]	(136)	(41)
Net interest	186	226
Average Nutrien Financial net receivables	3,561	3,311
Nutrien Financial adjusted net interest margin (%)	5.2	6.8

1 Average borrowing rate applied to the notional debt required to fund the portfolio of receivables from customers monitored and serviced by Nutrien Financial.

Retail cash operating coverage ratio

Definition: Retail selling, general and administrative, and other expenses (income), excluding depreciation and amortization expense, divided by Retail gross margin excluding depreciation and amortization expense in cost of goods sold, for the last four rolling quarters.

Why we use the measure and why it is useful to investors: To understand the costs and underlying economics of our Retail operations and to assess our Retail operating performance and ability to generate free cash flow.

(millions of US dollars, except as otherwise noted)	2023	2022
Selling expenses	3,375	3,392
General and administrative expenses	217	200
Other expenses	158	29
Operating expenses	3,750	3,621
Depreciation and amortization in operating expenses	(749)	(740)
Operating expenses excluding depreciation and amortization	3,001	2,881
Gross margin	4,430	5,179
Depreciation and amortization in cost of goods sold	10	12
Gross margin excluding depreciation and amortization	4,440	5,191
Cash operating coverage ratio (%)	68	55

Return on invested capital (“ROIC”)

Definition: ROIC is calculated as net operating profit after taxes divided by the average invested capital for the last four rolling quarters.

Net operating profit after taxes, a non-GAAP financial measure, is calculated as earnings before finance costs and income taxes, depreciation and amortization related to the fair value adjustments as a result of the Merger (the merger of equals transaction between PotashCorp and Agrium), share-based compensation, and certain foreign exchange gain/loss (net of related derivatives) and Nutrien Financial earnings before finance costs and income taxes. The most directly comparable IFRS financial measure to net operating profit after taxes is earnings before finance costs and income taxes. We also adjust this measure for the following other income and expenses that are excluded when management evaluates the performance of our day-to-day operations: integration and restructuring related costs, impairment or reversal of impairment of assets, COVID-19 related expenses, gain or loss on disposal of certain businesses and investments, and IFRS adoption transition adjustments. A tax rate of 25 percent is applied on the calculated amount. Prior to 2023, we were adjusting for Nutrien Financial revenue; however, in 2023, we updated our calculation to adjust for Nutrien Financial earnings before finance costs and income taxes to further refine our calculations.

Invested capital is calculated as last four rolling quarter average of total assets less cash and cash equivalents; payables and accrued charges; Merger fair value adjustments on goodwill, intangible assets, and property, plant and equipment; and average Nutrien Financial working capital.

We exclude in our calculations the related financial information of certain acquisitions during the first year following the acquisition.

Why we use the measure and why it is useful to investors: In 2022, we added a new financial measure to evaluate how efficiently we allocate our capital. ROIC provides useful information to evaluate our after-tax cash operating return on invested capital and is used as a component of employee remuneration calculations.

(millions of US dollars, except as otherwise noted)	2023	2022	2021
Earnings before finance costs and income taxes	2,745	10,809	4,781
Merger adjustments [1]	194	231	277
Integration and restructuring related costs	49	46	43
Share-based compensation (recovery) expense	(14)	63	198
Impairment (reversal of impairment) of assets	774	(780)	33
ARO/ERL expense for non-operating sites	152	–	–
COVID-19 related expenses	–	8	45
Foreign exchange loss, net of related derivatives	91	31	39
Loss on Blue Chip Swap transactions	92	–	–
Gain on disposal of investment	–	(19)	–
Cloud computing transition adjustment	–	–	36
Nutrien Financial earnings before finance costs and income taxes	(127)	(234)	(124)
Net operating profit	3,956	10,155	5,328
Tax (calculated at 25%)	989	2,539	1,332
Net operating profit after tax	2,967	7,616	3,996

1 Depreciation and amortization related to the fair value adjustments as a result of the Merger (the merger of equals transaction between PotashCorp and Agrium).

Total assets	53,874	54,228	48,880
Cash and cash equivalents	(926)	(753)	(862)
Payables and accrued charges	(9,050)	(10,687)	(8,773)
Merger adjustments [1]	(9,896)	(10,232)	(10,516)
Average Nutrien Financial receivables	(3,561)	(3,311)	(2,316)
Invested capital	30,441	29,245	26,413

1 Merger fair value adjustments on goodwill, intangible assets, and property, plant and equipment.

Return on invested capital (%)	10	26	15

Appendix B – other financial measures

Supplementary financial measures

Supplementary financial measures are financial measures disclosed by the Company that (a) are, or are intended to be, disclosed on a periodic basis to depict the historical or expected future financial performance, financial position or cash flow of the Company, (b) are not disclosed in the financial statements of the Company, (c) are not non-GAAP financial measures, and (d) are not non-GAAP ratios.

The following section provides an explanation of the composition of those supplementary financial measures if not previously provided.

Retail adjusted EBITDA margin: Retail adjusted EBITDA divided by Retail sales for the last four rolling quarters.

Sustaining capital expenditures: Represents capital expenditures that are required to sustain operations at existing levels and include major repairs and maintenance and plant turnarounds.

Investing capital expenditures: Represents capital expenditures related to significant expansions of current operations or to create cost savings (synergies). Investing capital expenditures excludes capital outlays for business acquisitions and equity-accounted investees.

Mine development and pre-stripping capital expenditures: Represents capital expenditures that are required for activities to open new areas underground and/or develop a mine or ore body to allow for future production mining and activities required to prepare and/or access the ore, i.e., removal of an overburden that allows access to the ore.

Retail adjusted EBITDA per US selling location: Calculated as total Retail US adjusted EBITDA for the last four rolling quarters, representing the organic EBITDA component, which excludes acquisitions in those quarters, divided by the number of US locations that have generated sales in the last four rolling quarters, adjusted for acquired locations in those quarters.

Cash used for dividends and share repurchases (shareholder returns): Calculated as dividends paid to Nutrien's shareholders plus repurchase of common shares as reflected in the consolidated statements of cash flows. This measure is useful as it represents return of capital to shareholders.

Capital management measures

Capital management measures are financial measures disclosed by the Company that (a) are intended to enable an individual to evaluate the Company's objectives, policies and processes for managing the Company's capital, (b) are not a component of a line item disclosed in the primary financial statements of the Company, (c) are disclosed in the notes of the financial statements of the Company, and (d) are not disclosed in the primary financial statements of the Company.

The following section outlines our capital management measure, its composition and why management uses the measure.

Adjusted net debt to adjusted EBITDA: Calculated as adjusted net debt to adjusted EBITDA. Both components are non-GAAP financial measures. This ratio measures financial leverage and our ability to pay our debt.

The most directly comparable measure for adjusted net debt is total short-term and long-term debt and lease liabilities less cash and cash equivalents and is defined as the total of short-term and long-term debt plus lease liabilities less cash and cash equivalents and unamortized fair value adjustments. This measure is useful as it adjusts for the unamortized fair value adjustments that arose at the time of the Merger and is non-cash in nature.

(millions of US dollars, except as otherwise noted)	2023	2022
Short-term debt	1,815	2,142
Current portion of long-term debt	512	542
Current portion of lease liabilities	327	305
Long-term debt	8,913	8,040
Lease liabilities	999	899
Total debt	12,566	11,928
Cash and cash equivalents	(941)	(901)
Unamortized fair value adjustments	(294)	(310)
Adjusted net debt	11,331	10,717

Five-year highlights

The following information is not part of our MD&A on SEDAR+ and EDGAR and is furnished for those readers who may find value in the use of such information over the long term.

Summary financial information

(millions of US dollars, except as otherwise noted)	2023	2022	2021	2020	2019
Operations					
Sales [1]	29,056	37,884	27,712	20,908	20,084
Earnings before finance costs and income taxes	2,745	10,809	4,781	902	1,862
Net earnings	1,282	7,687	3,179	459	992
Diluted net earnings per share (US dollars)	2.53	14.18	5.52	0.81	1.70
Finance costs	793	563	613	520	554
Adjusted EBITDA [2]	6,058	12,170	7,126	3,667	4,025
Cash provided by operating activities	5,066	8,110	3,886	3,323	3,665
Balance sheet					
Total assets	52,749	54,586	49,954	47,192	46,799
Short-term debt and long-term debt (including leases)	12,566	11,928	10,846	11,360	11,104
Total shareholders' equity	25,201	25,863	23,699	22,403	22,907
Common share information					
Weighted average common shares (millions)	497	540	571	570	583
Closing share price on NYSE (US dollars)	56.33	73.03	75.20	48.16	47.91
Operating segment information					
Retail net sales [1]	19,542	21,350	17,734	14,785	13,282
Potash net sales	3,759	7,899	4,036	2,146	2,604
Nitrogen net sales	4,207	7,533	4,689	2,740	2,848
Phosphate net sales	1,993	2,377	1,829	1,202	1,368
Retail adjusted EBITDA	1,459	2,293	1,939	1,430	1,231
Potash adjusted EBITDA	2,404	5,769	2,736	1,190	1,593
Nitrogen adjusted EBITDA	1,930	3,931	2,308	1,080	1,239
Phosphate adjusted EBITDA	470	594	540	232	194
Capital allocation					
Sustaining capital expenditures [3]	1,421	1,449	1,247	919	1,018
Investing capital expenditures [3]	988	792	510	511	772
Mine development and pre-stripping expenditures [3]	262	234	156	109	96
Business acquisitions (net of cash acquired)	153	407	88	233	911
Dividends paid to Nutrien's shareholders	1,032	1,031	1,045	1,030	1,022
Repurchase of common shares	1,047	4,520	1,035	160	1,930

1 Certain immaterial figures have been reclassified for 2019.
2 This is a non-GAAP financial measure. See the "Non-GAAP Financial Measures" section. Additional information relating to 2021, 2020 and 2019 is contained in the "Appendix – Non-IFRS Financial Measures" sections of Nutrien's MD&A dated February 17, 2022 for the year ended December 31, 2021, its MD&A dated February 17, 2021 for the year ended December 31, 2020 and its MD&A dated February 19, 2020 for the year ended December 31, 2019, respectively, which information is incorporated by reference herein. Such MD&A are available on SEDAR+ at sedarplus.ca.
3 These are supplementary financial measures. See the "Other Financial Measures" section.

Summary non-financial information

	2023	2022	2021	2020	2019
Safety					
Total recordable injury frequency [1]	1.01	1.16	1.11	1.13	1.29
Lost-time injury frequency [1]	0.24	0.24	0.27	0.26	0.31
Serious injury and fatality incidents	5	5	—	1	1
Environment					
Scope 1 and 2 GHG emissions (Mmt CO_2e)	12.2	12.8	13.8	13.2	13.3
CO_2 captured and sold (Mmt)	1.0	1.1	1.1	1.0	1.2
Sustainably engaged acres (millions) [2]	2	1	n/m	n/m	n/m
Community					
Community investment ($ millions)	23	33	19	18	17
Employees					
Permanent employees at December 31	25,900	24,700	23,500	23,100	22,300
Total employee turnover rate (%)	14	12	15	13	13
Proportion of women (%)	20	21	20	20	19
Proportion of women in senior leadership (%)	23	21	21	19	15

1 Restated 2019 to 2020 as a result of changes to classification of incidents.
2 Acres tracked in 2021 were part of the pilot program. Not applicable in 2019 to 2020.

Summary production and sales volumes information

	2023	2022	2021	2020	2019
Production (thousands)					
Potash production (product tonnes)	12,998	13,007	13,790	12,595	11,700
Nitrogen production (total ammonia tonnes) [1]	5,357	5,759	5,996	6,063	6,164
Phosphate production (P_2O_5 tonnes)	1,406	1,351	1,518	1,444	1,514
Sales of manufactured product tonnes (thousands)					
Retail crop nutrients tonnes sold	12,632	11,513	13,383	12,732	11,048
Potash tonnes sold	13,216	12,537	13,625	12,824	11,521
Nitrogen tonnes sold	10,423	10,023	10,725	10,966	10,270
Phosphate tonnes sold	2,551	2,378	2,619	2,781	2,889

1 All figures are provided on a gross production basis.

Financial statements and notes

Minas Gerais, Brazil

Brazil is home to almost 35 percent of the oranges produced in the world and more than half of the world's orange juice. Nutrien has over 180 Retail locations in Brazil, including the main orange producing area of Triângulo Mineiro, also known as the Citrus Belt.

Contents

Management's responsibility

Management's responsibility for financial reporting

Management's report on the consolidated financial statements

The accompanying consolidated financial statements and related financial information are the responsibility of the management of Nutrien Ltd. (the "Company"). They have been prepared in accordance with International Financial Reporting Standards ("IFRS") as issued by the International Accounting Standards Board and include amounts based on estimates and judgments. Financial information included elsewhere in this report is consistent with the consolidated financial statements.

The consolidated financial statements are approved by the Board of Directors on the recommendation of the Audit Committee. The Audit Committee, appointed by the Board of Directors, is composed entirely of independent directors. The Audit Committee discusses and analyzes the Company's condensed consolidated financial statements and Management's Discussion and Analysis ("MD&A") with management before such information is approved by the committee and submitted to securities commissions or other regulatory authorities. The Audit Committee and management also analyze the annual consolidated financial statements and MD&A prior to their approval by the Board of Directors.

The Audit Committee's duties also include reviewing critical accounting policies and significant estimates and judgments underlying the consolidated financial statements as presented by management and approving the fees of our independent registered public accounting firm.

Our independent registered public accounting firm, KPMG LLP, performs an audit of the consolidated financial statements, the results of which are reflected in their Report of Independent Registered Public Accounting Firm for 2023. KPMG LLP has full and independent access to the Audit Committee to discuss their audit and related matters.

Management's annual report on internal control over financial reporting

Management is responsible for establishing and maintaining adequate internal control over financial reporting, as defined in Rules 13a-15(f) and 15d-15(f) of the Securities Exchange Act of 1934, as amended, and National Instrument 52-109 – *Certification of Disclosure in Issuers' Annual and Interim Filings*. Internal control over financial reporting is designed to provide reasonable assurance regarding the reliability of financial reporting and preparation of financial statements for external purposes in accordance with IFRS.

Under our supervision and with the participation of management, the Company conducted an evaluation of the design and effectiveness of our internal control over financial reporting as of the end of the fiscal year covered by this report, based on the framework issued by the Committee of Sponsoring Organizations of the Treadway Commission in Internal Control – Integrated Framework (2013). Based on this evaluation, management concluded that, as of December 31, 2023, the Company did maintain effective internal control over financial reporting.

The effectiveness of the Company's internal control over financial reporting as of December 31, 2023 has been audited by KPMG LLP, as reflected in their Report of Independent Registered Public Accounting Firm for 2023.

Ken Seitz
President and Chief Executive Officer
February 22, 2024

Pedro Farah
Executive Vice President and Chief Financial Officer
February 22, 2024

Report of independent registered public accounting firm

To the shareholders and Board of Directors of Nutrien Ltd.

Opinion on internal control over financial reporting

We have audited Nutrien Ltd. and subsidiaries' (the "Company") internal control over financial reporting as of December 31, 2023, based on criteria established in Internal Control – Integrated Framework (2013) issued by the Committee of Sponsoring Organizations of the Treadway Commission. In our opinion, the Company maintained, in all material respects, effective internal control over financial reporting as of December 31, 2023, based on criteria established in Internal Control – Integrated Framework (2013) issued by the Committee of Sponsoring Organizations of the Treadway Commission.

We also have audited, in accordance with the standards of the Public Company Accounting Oversight Board (United States) ("PCAOB"), the consolidated balance sheets of the Company as of December 31, 2023 and 2022, the related consolidated statements of earnings, comprehensive income, cash flows, and changes in shareholders' equity for the years then ended, and the related notes (collectively, the "consolidated financial statements"), and our report dated February 22, 2024 expressed an unqualified opinion on those consolidated financial statements.

Basis for opinion

The Company's management is responsible for maintaining effective internal control over financial reporting and for its assessment of the effectiveness of internal control over financial reporting, included in the accompanying Management's Annual Report on Internal Control Over Financial Reporting. Our responsibility is to express an opinion on the Company's internal control over financial reporting based on our audit. We are a public accounting firm registered with the PCAOB and are required to be independent with respect to the Company in accordance with the US federal securities laws and the applicable rules and regulations of the Securities and Exchange Commission and the PCAOB.

We conducted our audit in accordance with the standards of the PCAOB. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether effective internal control over financial reporting was maintained in all material respects. Our audit of internal control over financial reporting included obtaining an understanding of internal control over financial reporting, assessing the risk that a material weakness exists, and testing and evaluating the design and operating effectiveness of internal control based on the assessed risk. Our audit also included performing such other procedures as we considered necessary in the circumstances. We believe that our audit provides a reasonable basis for our opinion.

Definition and limitations of internal control over financial reporting

A company's internal control over financial reporting is a process designed to provide reasonable assurance regarding the reliability of financial reporting and the preparation of financial statements for external purposes in accordance with generally accepted accounting principles. A company's internal control over financial reporting includes those policies and procedures that (1) pertain to the maintenance of records that, in reasonable detail, accurately and fairly reflect the transactions and dispositions of the assets of the company; (2) provide reasonable assurance that transactions are recorded as necessary to permit preparation of financial statements in accordance with generally accepted accounting principles, and that receipts and expenditures of the company are being made only in accordance with authorizations of management and directors of the company; and (3) provide reasonable assurance regarding prevention or timely detection of unauthorized acquisition, use, or disposition of the company's assets that could have a material effect on the financial statements.

Because of its inherent limitations, internal control over financial reporting may not prevent or detect misstatements. Also, projections of any evaluation of effectiveness to future periods are subject to the risk that controls may become inadequate because of changes in conditions, or that the degree of compliance with the policies or procedures may deteriorate.

KPMG LLP

Chartered Professional Accountants

Calgary, Canada
February 22, 2024

Report of independent registered public accounting firm

To the shareholders and Board of Directors of Nutrien Ltd.

Opinion on the consolidated financial statements

We have audited the accompanying consolidated balance sheets of Nutrien Ltd. and subsidiaries (the "Company") as of December 31, 2023 and 2022, the related consolidated statements of earnings, comprehensive income, cash flows, and changes in shareholders' equity for the years then ended, and the related notes (collectively, the "consolidated financial statements"). In our opinion, the consolidated financial statements present fairly, in all material respects, the financial position of the Company as of December 31, 2023 and 2022, and its financial performance and its cash flows for the years then ended, in conformity with International Financial Reporting Standards as issued by the International Accounting Standards Board.

We also have audited, in accordance with the standards of the Public Company Accounting Oversight Board (United States) ("PCAOB"), the Company's internal control over financial reporting as of December 31, 2023, based on criteria established in Internal Control – Integrated Framework (2013) issued by the Committee of Sponsoring Organizations of the Treadway Commission, and our report dated February 22, 2024 expressed an unqualified opinion on the effectiveness of the Company's internal control over financial reporting.

Basis for opinion

These consolidated financial statements are the responsibility of the Company's management. Our responsibility is to express an opinion on these consolidated financial statements based on our audits. We are a public accounting firm registered with the PCAOB and are required to be independent with respect to the Company in accordance with the US federal securities laws and the applicable rules and regulations of the Securities and Exchange Commission and the PCAOB.

We conducted our audits in accordance with the standards of the PCAOB. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether the consolidated financial statements are free of material misstatement, whether due to error or fraud. Our audits included performing procedures to assess the risks of material misstatement of the consolidated financial statements, whether due to error or fraud, and performing procedures that respond to those risks. Such procedures included examining, on a test basis, evidence regarding the amounts and disclosures in the consolidated financial statements. Our audits also included evaluating the accounting principles used and significant estimates made by management, as well as evaluating the overall presentation of the consolidated financial statements. We believe that our audits provide a reasonable basis for our opinion.

Critical audit matters

The critical audit matters communicated below are matters arising from the current period audit of the consolidated financial statements that were communicated or required to be communicated to the Audit Committee and that: (1) relate to accounts or disclosures that are material to the consolidated financial statements and (2) involved our especially challenging, subjective, or complex judgments. The communication of critical audit matters does not alter in any way our opinion on the consolidated financial statements, taken as a whole, and we are not, by communicating the critical audit matters below, providing separate opinions on the critical audit matters or on the accounts or disclosures to which they relate.

Goodwill impairment assessment of the Retail North America group of cash-generating units

As discussed in Note 14 to the consolidated financial statements, the carrying amount of goodwill as of December 31, 2023 was $12,114 million, of which $6,981 million of goodwill is attributed to the Retail North America group of cash-generating units ("Retail North America CGU"). The Retail North America CGU is tested for impairment annually, and whenever events or changes in circumstances may indicate the carrying amount, including goodwill, exceeds its estimated recoverable amount. The calculation of the recoverable amount of the Retail North America CGU involved estimates including forecasted earnings before tax, interest, depreciation and amortization ("EBITDA"), terminal growth rate and the discount rate.

We identified the calculation of the recoverable amount of goodwill for the Retail North America CGU as of October 1, 2023 as a critical audit matter. A high degree of auditor judgment was required to evaluate the Company's forecasted EBITDA, terminal growth rate and discount rate used to calculate the recoverable amount of the Retail North America CGU. Minor changes to

these assumptions could have had a significant effect on the Company's calculation of the recoverable amount of the Retail North America CGU. Additionally, the audit effort associated with this estimate required specialized skills and knowledge.

The following are the primary procedures we performed to address this critical audit matter. We evaluated the design and tested the operating effectiveness of certain internal controls related to the calculation of the recoverable amount of goodwill for the Retail North America CGU. This included controls related to the determination of forecasted EBITDA, terminal growth rate and the discount rate. We evaluated the Company's forecasted EBITDA for the Retail North America CGU by comparing to historical results and forecasted planted acreage in the United States. We evaluated the terminal growth rate by comparing to the historical growth of the Retail North America CGU and to market information, including forecasted inflation and forecasted gross domestic product in the United States. We evaluated the Company's historical forecasts of EBITDA by comparing to actual results to assess the Company's ability to accurately forecast. In addition, we involved valuation professionals with specialized skills and knowledge, who assisted in:

- evaluating the Company's determination of the discount rate by comparing the inputs to the discount rate to publicly available market data for comparable entities and assessing the resulting discount rate, and
- evaluating the Company's estimate of the recoverable amount of the Retail North America CGU by comparing the results of the Company's estimate to publicly available market data and valuation metrics for comparable entities.

Goodwill impairment assessment of the Retail South America group of cash-generating units

As discussed in Note 14 to the consolidated financial statements, the Company recorded impairment of $422 million to goodwill and $43 million to intangible assets of the Retail South America group of cash-generating units ("Retail South America CGU") during the year ended December 31, 2023. The Retail South America CGU is tested for impairment annually, and whenever events or changes in circumstances may indicate the carrying amount, including goodwill, exceeds its estimated recoverable amount. An indicator of impairment was identified as of June 30, 2023 due to a reduction to forecasted earnings and growth. The calculation of the recoverable amount of the Retail South America CGU involved estimates including forecasted earnings before tax, interest, depreciation and amortization ("EBITDA"), terminal growth rate and the discount rate.

We identified the calculation of the recoverable amount of the Retail South America CGU as of June 30, 2023 as a critical audit matter. A high degree of auditor judgment was required to evaluate the Company's forecasted EBITDA, terminal growth rate and discount rate used to calculate the recoverable amount of the Retail South America CGU. The forecasted EBITDA and terminal growth rate assumptions were challenging to test as they represented subjective determinations of future market and economic conditions that were also sensitive to variation. Additionally, the audit effort associated with this estimate required specialized skills and knowledge.

The following are the primary procedures we performed to address this critical audit matter. We evaluated the design and tested the operating effectiveness of certain internal controls related to the calculation of the recoverable amount of the Retail South America CGU. This included controls related to the determination of forecasted EBITDA, terminal growth rate and the discount rate. We evaluated the Company's forecasted EBITDA for the Retail South America CGU by comparing to historical results and external market forecasts of planted acreage and exports. We evaluated the terminal growth rate by comparing to the historical growth of the Retail South America CGU and to market information, including forecasted inflation and forecasted gross domestic product in Brazil and Argentina. We evaluated the Company's historical forecasts of EBITDA by comparing to actual results to assess the Company's ability to accurately forecast. In addition, we involved valuation professionals with specialized skills and knowledge, who assisted in:

- evaluating the Company's determination of the discount rate by comparing the inputs to the discount rate to publicly available market data for comparable entities and assessing the resulting discount rate, and
- evaluating the Company's estimate of the recoverable amount of the Retail South America CGU by comparing the results of the Company's estimate to publicly available market data and valuation metrics for comparable entities.

KPMG LLP

Chartered Professional Accountants

We have served as the Company's auditor since 2018.

Calgary, Canada
February 22, 2024

Consolidated statements of earnings

For the years ended December 31	Note	2023	2022
Sales	3	29,056	37,884
Freight, transportation and distribution	4	974	872
Cost of goods sold	4, 12	19,608	21,588
Gross margin		8,474	15,424
Selling expenses	4	3,397	3,414
General and administrative expenses	4	626	565
Provincial mining taxes	4	398	1,149
Share-based compensation (recovery) expense	5	(14)	63
Impairment (reversal of impairment) of assets	13, 14	774	(780)
Other expenses	6	548	204
Earnings before finance costs and income taxes		2,745	10,809
Finance costs	7	793	563
Earnings before income taxes		1,952	10,246
Income tax expense	8	670	2,559
Net earnings		1,282	7,687
Attributable to			
Equity holders of Nutrien		1,258	7,660
Non-controlling interest		24	27
Net earnings		1,282	7,687
Net earnings per share attributable to equity holders of Nutrien ("EPS")	9		
Basic		2.53	14.22
Diluted		2.53	14.18
Weighted average shares outstanding for basic EPS	9	496,381,000	538,475,000
Weighted average shares outstanding for diluted EPS	9	496,994,000	540,010,000

Consolidated statements of comprehensive income

For the years ended December 31 (net of related income taxes)	Note	2023	2022
Net earnings		1,282	7,687
Other comprehensive income (loss)			
Items that will not be reclassified to net earnings:			
Net actuarial (loss) gain on defined benefit plans	21	(17)	83
Net fair value gain (loss) on investments	15	4	(44)
Items that have been or may be subsequently reclassified to net earnings:			
Gain (loss) on currency translation of foreign operations		89	(199)
Other		5	(17)
Other comprehensive income (loss)		81	(177)
Comprehensive income		1,363	7,510
Attributable to			
Equity holders of Nutrien		1,338	7,484
Non-controlling interest		25	26
Comprehensive income		1,363	7,510

(See Notes to the consolidated financial statements)

In millions of US dollars unless otherwise noted

Consolidated statements of cash flows

For the years ended December 31	Note	2023	2022
			Note 2
Operating activities			
Net earnings		1,282	7,687
Adjustments for:			
Depreciation and amortization		2,169	2,012
Share-based compensation (recovery) expense	5	(14)	63
Impairment (reversal of impairment) of assets	13, 14	774	(780)
Provision for deferred income tax		7	182
Net distributed (undistributed) earnings of equity-accounted investees		117	(181)
Gain on amendments to other post-retirement pension plans	21	(80)	–
Loss on Blue Chip Swaps	6	92	–
Long-term income tax receivables and payables	16	(65)	273
Other long-term assets, liabilities and miscellaneous		277	2
Cash from operations before working capital changes		4,559	9,258
Changes in non-cash operating working capital:			
Receivables		879	(919)
Inventories and prepaid expenses and other current assets		1,376	(1,167)
Payables and accrued charges		(1,748)	938
Cash provided by operating activities		5,066	8,110
Investing activities			
Capital expenditures[1]	13, 14	(2,671)	(2,475)
Business acquisitions, net of cash acquired	25	(153)	(407)
Proceeds from sales of Blue Chip Swaps, net of purchases	6	(92)	–
Net changes in non-cash working capital		(22)	(44)
Other		(20)	25
Cash used in investing activities		(2,958)	(2,901)
Financing activities			
(Repayment of) proceeds from short-term debt, net	17, 18	(458)	529
Proceeds from long-term debt	18	1,500	1,045
Repayment of long-term debt	18	(648)	(561)
Repayment of principal portion of lease liabilities	18, 19	(375)	(341)
Dividends paid to Nutrien's shareholders	23	(1,032)	(1,031)
Repurchase of common shares	23	(1,047)	(4,520)
Issuance of common shares	23	33	168
Other		(34)	(20)
Cash used in financing activities		(2,061)	(4,731)
Effect of exchange rate changes on cash and cash equivalents		(7)	(76)
Increase in cash and cash equivalents		40	402
Cash and cash equivalents – beginning of year		901	499
Cash and cash equivalents – end of year		941	901
Cash and cash equivalents is composed of:			
Cash		909	775
Short-term investments		32	126
		941	901
Supplemental cash flows information			
Interest paid		729	482
Income taxes paid		1,764	1,882
Total cash outflow for leases		501	459

1 Includes additions to property, plant and equipment, and intangible assets of $2,465 and $206 (2022 – $2,253 and $222), respectively.

(See Notes to the consolidated financial statements)

In millions of US dollars unless otherwise noted

Consolidated statements of changes in shareholders' equity

	Number of common shares	Share capital	Contributed surplus	Accumulated other comprehensive (loss) income ("AOCI"): (Loss) gain on currency translation of foreign operations	AOCI: Other	AOCI: Total AOCI	Retained earnings	Equity holders of Nutrien	Non-controlling interest	Total equity
Balance – December 31, 2021	557,492,516	15,457	149	(176)	30	(146)	8,192	23,652	47	23,699
Net earnings	–	–	–	–	–	–	7,660	7,660	27	7,687
Other comprehensive (loss) income	–	–	–	(198)	22	(176)	–	(176)	(1)	(177)
Shares repurchased (Note 23)	(53,312,559)	(1,487)	(22)	–	–	–	(2,987)	(4,496)	–	(4,496)
Dividends declared (Note 23)	–	–	–	–	–	–	(1,019)	(1,019)	–	(1,019)
Non-controlling interest transactions	–	–	–	–	–	–	(1)	(1)	(28)	(29)
Effect of share-based compensation including issuance of common shares (Note 5)	3,066,148	202	(18)	–	–	–	–	184	–	184
Transfer of net loss on cash flow hedges	–	–	–	–	14	14	–	14	–	14
Transfer of net actuarial gain on defined benefit plans	–	–	–	–	(83)	(83)	83	–	–	–
Balance – December 31, 2022	507,246,105	14,172	109	(374)	(17)	(391)	11,928	25,818	45	25,863
Net earnings	–	–	–	–	–	–	1,258	1,258	24	1,282
Other comprehensive income (loss)	–	–	–	88	(8)	80	–	80	1	81
Shares repurchased (Note 23)	(13,378,189)	(374)	(26)	–	–	–	(600)	(1,000)	–	(1,000)
Dividends declared (Note 23)	–	–	–	–	–	–	(1,050)	(1,050)	–	(1,050)
Non-controlling interest transactions	–	–	–	–	–	–	(2)	(2)	(25)	(27)
Effect of share-based compensation including issuance of common shares (Note 5)	683,814	40	–	–	–	–	–	40	–	40
Transfer of net gain on sale of investment	–	–	–	–	(14)	(14)	14	–	–	–
Transfer of net loss on cash flow hedges	–	–	–	–	12	12	–	12	–	12
Transfer of net actuarial loss on defined benefit plans	–	–	–	–	17	17	(17)	–	–	–
Balance – December 31, 2023	494,551,730	13,838	83	(286)	(10)	(296)	11,531	25,156	45	25,201

(See Notes to the consolidated financial statements)

In millions of US dollars unless otherwise noted

Consolidated balance sheets

As at December 31	Note	2023	2022
Assets			
Current assets			
Cash and cash equivalents		941	901
Receivables	11	5,398	6,194
Inventories	12	6,336	7,632
Prepaid expenses and other current assets		1,495	1,615
		14,170	16,342
Non-current assets			
Property, plant and equipment	13	22,461	21,767
Goodwill	14	12,114	12,368
Intangible assets	14	2,217	2,297
Investments	15	736	843
Other assets	16	1,051	969
Total assets		52,749	54,586
Liabilities			
Current liabilities			
Short-term debt	17	1,815	2,142
Current portion of long-term debt	18	512	542
Current portion of lease liabilities	19	327	305
Payables and accrued charges	20	9,467	11,291
		12,121	14,280
Non-current liabilities			
Long-term debt	18	8,913	8,040
Lease liabilities	19	999	899
Deferred income tax liabilities	8	3,574	3,547
Pension and other post-retirement benefit liabilities	21	252	319
Asset retirement obligations and accrued environmental costs	22	1,489	1,403
Other non-current liabilities		200	235
Total liabilities		27,548	28,723
Shareholders' equity			
Share capital	23	13,838	14,172
Contributed surplus		83	109
Accumulated other comprehensive loss		(296)	(391)
Retained earnings		11,531	11,928
Equity holders of Nutrien		25,156	25,818
Non-controlling interest		45	45
Total shareholders' equity		25,201	25,863
Total liabilities and shareholders' equity		52,749	54,586

(See Notes to the consolidated financial statements)

Approved by the Board of Directors,

Christopher Burley

Director

Director

In millions of US dollars unless otherwise noted

Notes to the consolidated financial statements

Note 1 | Description of business

Nutrien Ltd. (collectively with its subsidiaries, "Nutrien", "we", "us", "our" or "the Company") is the world's largest provider of crop inputs and services. Nutrien plays a critical role in helping growers around the globe increase food production in a sustainable manner.

The Company is a corporation organized under the laws of Canada with its registered head office located at Suite 1700, 211 19th Street East, Saskatoon, Saskatchewan, Canada, S7K 5R6. As at December 31, 2023, the Company had assets, which include as follows:

Segment	Description
Nutrien Ag Solutions ("Retail")	– various retail facilities across the US, Canada, Australia and South America – private label and proprietary crop protection products and nutritionals – an innovative integrated digital platform for growers and crop consultants – a financing solutions provider in support of Nutrien's agricultural product and service sales
Potash	– 6 operations in the province of Saskatchewan – investment in Canpotex Limited ("Canpotex"), a Canadian potash export, sales and marketing company owned in equal shares by Nutrien and another potash producer
Nitrogen	– 8 production facilities in North America: 4 in Alberta, 1 in Georgia, 1 in Louisiana, 1 in Ohio and 1 in Texas – 1 large-scale operation in Trinidad – 5 upgrade facilities in North America: 3 in Alberta, 1 in Missouri and 1 in Washington – 50 percent investment in Profertil S.A. ("Profertil"), a nitrogen producer based in Argentina
Phosphate	– 2 mines and processing plants: 1 in Florida and 1 in North Carolina – phosphate feed plants in Illinois, Missouri and Nebraska – 1 industrial phosphoric acid plant in Ohio
Corporate and Others	– 22 percent investment in Sinofert Holdings Limited ("Sinofert"), a fertilizer supplier and distributor in China – corporate offices in the US and Canada and other non-operating sites

Note 2 | Basis of presentation

We prepared these consolidated financial statements in accordance with International Financial Reporting Standards ("IFRS") as issued by the International Accounting Standards Board ("IASB"). We have consistently applied the same accounting policies throughout all periods presented, as if these policies had always been in effect, with the exception of the accounting standards adopted effective January 1, 2023, as disclosed in Note 30.

Certain immaterial 2022 figures have been reclassified in the consolidated statements of cash flows.

These consolidated financial statements were authorized for issue by the Board of Directors on February 22, 2024.

Sensitivity analyses included throughout the notes should be used with caution as the changes are hypothetical and not reflective of future performance. The sensitivities have been calculated independently of changes in other key variables. We prepared these consolidated financial statements under the historical cost basis, except for items that IFRS requires to be measured at fair value. Reference to n/a indicates information is not applicable.

In millions of US dollars unless otherwise noted

Note 3 | Segment information

The Company has four reportable operating segments: Nutrien Ag Solutions ("Retail"), Potash, Nitrogen and Phosphate. The Retail segment distributes crop nutrients, crop protection products, seed and merchandise. Retail provides services directly to growers through a network of retail locations in North America, South America and Australia. The Potash, Nitrogen and Phosphate segments are differentiated by the chemical nutrient contained in the products that each produces.

The Executive Leadership Team ("ELT"), comprised of officers at the Executive Vice President level and above, is the Chief Operating Decision Maker ("CODM"). The CODM uses adjusted EBITDA, calculated as below, to measure performance and allocate resources to the operating segments. The CODM considers adjusted EBITDA to be a meaningful measure because it is not impacted by long-term investment and financing decisions, but rather focuses on the performance of our day-to-day operations. In addition, it excludes the impact of impairments and other costs that are centrally managed by our corporate function.

We determine the composition of the reportable segments based on factors including risks and returns, internal organization, and internal reports reviewed by the CODM. We allocate certain expenses across segments based on reasonable considerations such as production capabilities or historical trends.

2023	Retail	Potash	Nitrogen	Phosphate	Corporate and Others	Eliminations	Consolidated
Sales – third party	19,542	3,735	3,804	1,975	–	–	29,056
– intersegment	–	431	931	288	–	(1,650)	–
Sales – total	19,542	4,166	4,735	2,263	–	(1,650)	29,056
Freight, transportation and distribution	–	407	528	270	–	(231)	974
Net sales	19,542	3,759	4,207	1,993	–	(1,419)	28,082
Cost of goods sold	15,112	1,396	2,828	1,760	–	(1,488)	19,608
Gross margin	4,430	2,363	1,379	233	–	69	8,474
Selling expenses	3,375	12	27	6	–	(23)	3,397
General and administrative expenses	217	13	21	11	364	–	626
Provincial mining taxes	–	398	–	–	–	–	398
Share-based compensation recovery	–	–	–	–	(14)	–	(14)
Impairment of assets (Notes 13 and 14)	465	–	76	233	–	–	774
Other expenses (income)	158	(1)	(27)	40	348	30	548
Earnings (loss) before finance costs and income taxes	215	1,941	1,282	(57)	(698)	62	2,745
Depreciation and amortization	759	463	572	294	81	–	2,169
EBITDA[1]	974	2,404	1,854	237	(617)	62	4,914
Integration and restructuring related costs	20	–	–	–	29	–	49
Share-based compensation recovery	–	–	–	–	(14)	–	(14)
Impairment of assets (Notes 13 and 14)	465	–	76	233	–	–	774
ARO/ERL expense for non-operating sites[2]	–	–	–	–	152	–	152
Foreign exchange loss, net of related derivatives	–	–	–	–	91	–	91
Loss on Blue Chip Swaps	–	–	–	–	92	–	92
Adjusted EBITDA	1,459	2,404	1,930	470	(267)	62	6,058
Assets	23,056	13,571	11,466	2,438	2,818	(600)	52,749

1 EBITDA is calculated as net earnings (loss) before finance costs, income taxes, and depreciation and amortization.
2 ARO/ERL refers to asset retirement obligations and accrued environmental costs.

In millions of US dollars unless otherwise noted APPX ATT_V3_1492 Nutrien Annual Report 2023 103

2022	Retail	Potash	Nitrogen	Phosphate	Corporate and Others	Eliminations	Consolidated
Sales – third party	21,266	7,600	6,755	2,263	–	–	37,884
– intersegment	84	599	1,293	357	–	(2,333)	–
Sales – total	21,350	8,199	8,048	2,620	–	(2,333)	37,884
Freight, transportation and distribution	–	300	515	243	–	(186)	872
Net sales	21,350	7,899	7,533	2,377	–	(2,147)	37,012
Cost of goods sold	16,171	1,400	4,252	1,884	–	(2,119)	21,588
Gross margin	5,179	6,499	3,281	493	–	(28)	15,424
Selling expenses	3,392	10	28	7	(1)	(22)	3,414
General and administrative expenses	200	9	17	13	326	–	565
Provincial mining taxes	–	1,149	–	–	–	–	1,149
Share-based compensation expense	–	–	–	–	63	–	63
Reversal of impairment of assets (Note 13)	–	–	–	(780)	–	–	(780)
Other expenses (income)	29	5	(137)	67	227	13	204
Earnings (loss) before finance costs and income taxes	1,558	5,326	3,373	1,186	(615)	(19)	10,809
Depreciation and amortization	752	443	558	188	71	–	2,012
EBITDA	2,310	5,769	3,931	1,374	(544)	(19)	12,821
Integration and restructuring related costs	2	–	–	–	44	–	46
Share-based compensation expense	–	–	–	–	63	–	63
Reversal of impairment of assets (Note 13)	–	–	–	(780)	–	–	(780)
COVID-19 coronavirus pandemic ("COVID-19") related expenses	–	–	–	–	8	–	8
Foreign exchange loss, net of related derivatives	–	–	–	–	31	–	31
Gain on disposal of investment	(19)	–	–	–	–	–	(19)
Adjusted EBITDA	2,293	5,769	3,931	594	(398)	(19)	12,170
Assets	24,451	13,921	11,807	2,661	2,622	(876)	54,586

Retail segment product line	Sales
Crop nutrients	Dry and liquid macronutrient products including potash, nitrogen and phosphate, and proprietary liquid micronutrient products.
Crop protection products	Various third-party supplier and proprietary products designed to maintain crop quality and manage plant diseases, weeds and other pests.
Seed	Various third-party supplier seed brands and proprietary seed product lines.
Merchandise	Fencing, feed supplements, livestock-related animal health products, storage and irrigation equipment, and other products.
Nutrien Financial	Financing solutions provided to US and Australia Retail branches and customers in support of Nutrien's agricultural product and service sales.
Services and other revenues	Product application, soil and leaf testing, crop scouting and precision agriculture services, and water services.

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Segment	Products	Sales prices impacted by
Potash	– North America – primarily granular – Offshore (international) – primarily granular and standard	– North American prices referenced at delivered prices (including transportation and distribution costs) – International prices pursuant to term and spot contract prices (excluding transportation and distribution costs)
Nitrogen	– Ammonia, urea and environmentally smart nitrogen ("ESN®"), and nitrogen solutions, nitrates and sulfates	– Global energy costs and supply
Phosphate	– Solid and liquid fertilizers, and industrial and feed products	– Global prices and supplies of ammonia and sulfur

	2023	2022
Retail sales by product line		
Crop nutrients	8,379	10,060
Crop protection products	6,750	7,067
Seed	2,295	2,112
Merchandise	1,001	1,019
Nutrien Financial	322	267
Services and other	927	966
Nutrien Financial elimination [1]	(132)	(141)
	19,542	21,350
Potash sales by geography		
Manufactured product		
North America	2,090	2,785
Offshore [2]	2,076	5,414
	4,166	8,199
Nitrogen sales by product line		
Manufactured product		
Ammonia	1,337	2,834
Urea and ESN® [3]	1,624	2,268
Solutions, nitrates and sulfates	1,367	1,996
Other nitrogen and purchased products [3]	407	950
	4,735	8,048
Phosphate sales by product line		
Manufactured product		
Fertilizer	1,264	1,520
Industrial and feed	703	763
Other phosphate and purchased products	296	337
	2,263	2,620

1 Represents elimination of the interest and service fees charged by Nutrien Financial to Retail branches.
2 Relates to Canpotex, a major customer, and includes other revenue representing provisional pricing adjustments of $(394) (2022 – $(105)) (Note 28).
3 Certain immaterial 2022 figures have been reclassified.

In millions of US dollars unless otherwise noted

	Sales – third party by customer location		Non-current assets [1]	
	2023	2022	2023	2022
United States	17,656	20,089	16,001	15,971
Canada	3,111	3,783	18,987	18,303
Australia	3,389	3,877	1,069	1,105
Canpotex (Note 28)	2,076	5,414	–	–
Trinidad	29	15	661	688
Brazil	1,048	1,136	555	851
Other South America	876 [2]	1,507 [2]	48	64
Other	871 [3]	2,063 [3]	389	457
	29,056	37,884	37,710	37,439

1 Excludes financial instruments (other than equity-accounted investees), deferred tax assets and post-employment benefit assets.
2 Other South America third-party sales includes sales to Argentina of $526 (2022 – $666).
3 Other third-party sales primarily relate to Europe of $314 (2022 – $856) and Others of $557 (2022 – $1,207).

Canpotex sales by market (%)	2023	2022
Latin America	47	34
Other Asian markets [1]	28	34
China	9	14
India	5	8
Other markets	11	10

1 All Asian markets except China and India.

Note 4 | Nature of expenses

	2023	2022
Purchased and produced raw materials and product for resale [1]	16,635	18,747
Depreciation and amortization	2,169	2,012
Employee costs [2]	2,858	2,968
Freight	1,171	1,094
Impairment (reversal of impairment) of assets (Notes 13 and 14)	774	(780)
Provincial mining taxes [3]	398	1,149
Integration and restructuring related costs	49	46
Contract services	753	745
Lease expense	103	93
Fleet fuel, repairs and maintenance	369	359
Gain on disposal of investment	–	(19)
COVID-19 related expenses	–	8
Loss on Blue Chip Swaps	92	–
ARO/ERL non-accretion expense (Note 22)	143	15
Gain on amendments to other post-retirement pension plans	(80)	–
Other	877	638
Total cost of goods sold and expenses	26,311	27,075

1 Significant expenses include supplies, energy, fuel, purchases of raw material (natural gas – feedstock, sulfur, ammonia and reagents) and product for resale (crop nutrients, crop protection products and seed).
2 Includes salaries and wages, employee benefits, and share-based compensation.
3 Includes Saskatchewan potash production tax and Saskatchewan resource surcharge of $279 and $119 (2022 – $909 and $240), respectively, as required under Saskatchewan provincial legislation.

In millions of US dollars unless otherwise noted

Note 5 | Share-based compensation

Plans	Eligibility	Granted	Vesting period	Maximum term	Settlement
Stock Options	Officers and eligible employees	Annually	25 percent per year over four years	10 years	Shares [1]
Performance Share Units ("PSUs")	Officers and eligible employees	Annually	On third anniversary of grant date based on total shareholder return relative to PSU peer group (75 percent weighting) and return on invested capital (25 percent weighting)	Not applicable	Cash
Restricted Share Units ("RSUs")	Officers and eligible employees	Annually	On third anniversary of grant date and not subject to performance conditions	Not applicable	Cash
Deferred Share Units ("DSUs")	Non-executive directors	At the discretion of the Board of Directors	Fully vest upon grant	Not applicable	Cash [2]
Stock Appreciation Rights ("SARs")/Tandem Stock Appreciation Rights ("TSARs") [3]	Awards no longer granted; legacy awards only	Awards no longer granted; legacy awards only	25 percent per year over four years	10 years	Cash

1 Stock options may also be settled by cash settlement or, if approved by the Company, by a broker-assisted "cashless exercise" arrangement or a "net exercise" arrangement.
2 Directors can redeem their DSUs for cash only when they leave the Board of Directors for an amount equal to the market value of the common shares at the time of redemption or as mandated by the Nutrien DSU Plan.
3 Holders of TSARs have the ability to choose between (a) receiving in cash the price of our shares on the date of exercise in excess of the exercise price of the right or (b) receiving common shares by paying the exercise price of the right. Our past experience and future expectation are that substantially all TSAR holders will elect to choose the first option.

The weighted average assumptions of stock options by year of grant that impacted current year results are as follows:

		Year of grant	
Stock options	**Based on**	**2023**	**2022**
Weighted average grant date fair value per option	Black-Scholes-Merton option-pricing model as of the date of the grant	25.67	20.49
Weighted average assumptions:			
Exercise price per option	Quoted market closing price of common shares on the last trading day immediately preceding the date of the grant	78.95	77.50
Expected annual dividend yield (%)	Annualized dividend rate as of the date of the grant	2.49	2.45
Expected volatility (%)	Historical volatility of Nutrien's shares over a period commensurate with the expected life of the grant	33	30
Risk-free interest rate (%)	Zero-coupon government issues implied yield available on equivalent remaining term at the time of the grant	3.84	2.00
Average expected life of options (years)	Historical experience	8.5	8.5

In millions of US dollars unless otherwise noted

	Units granted in 2023	Units outstanding as at December 31, 2023	Compensation expense 2023	2022
Stock options	301,168	3,248,306	8	11
PSUs	517,219	1,732,785	(39)	13
RSUs	582,659	1,576,486	23	33
DSUs	34,075	401,296	(4)	2
SARs/TSARs	–	176,284	(2)	4
			(14)	63

Note 6 | Other expenses (income)

	2023	2022
Integration and restructuring related costs	49	46
Foreign exchange loss, net of related derivatives	91	31
Earnings of equity-accounted investees	(101)	(247)
Bad debt expense	55	12
COVID-19 related expenses	–	8
Gain on disposal of investment	–	(19)
Project feasibility costs	86	79
Customer prepayment costs	47	42
Legal expenses	34	21
Consulting expenses	21	29
Employee special recognition award	–	61
Loss on Blue Chip Swaps	92	–
ARO/ERL expense for non-operating sites (Note 22)	152	–
Gain on amendments to other post-retirement pension plans	(80)	–
Other expenses	102	141
	548	204

The Central Bank of Argentina maintains certain currency controls that limit our ability to remit cash from Argentina. Blue Chip Swaps are trade transactions that effectively allow companies to transfer US dollars out of Argentina. Through this mechanism, we incurred a loss of $92 from the purchase of securities denominated in Argentine peso and corresponding sales in US dollars during 2023. The loss is a result of the significant divergence between the Blue Chip Swap market exchange rate and the official Argentinian Central Bank rate.

Note 7 | Finance costs

	2023	2022
Interest expense		
Short-term debt	303	153
Long-term debt	446	333
Lease liabilities	48	35
Total interest expense	797	521
Unwinding of discount on asset retirement obligations (Note 22)	33	29
Interest on net defined benefit pension and other post-retirement plan obligations (Note 21)	5	8
Borrowing costs capitalized to property, plant and equipment	(71)	(37)
Interest income	(35)	(25)
Other finance costs	64	67
	793	563

Borrowing costs capitalized to property, plant and equipment in 2023 were calculated by applying an average capitalization rate of 5.4 percent (2022 – 4.1 percent) to expenditures on qualifying assets.

In millions of US dollars unless otherwise noted

Note 8 | Income taxes

	2023	2022
Current income tax		
Tax expense for current year	637	2,314
Adjustments in respect of prior years	26	63
Total current income tax expense	663	2,377
Deferred income tax		
Origination and reversal of temporary differences	5	215
Swiss Tax Reform adjustment	(134)	–
Adjustments in respect of prior years	31	(41)
Change in recognition of tax losses and deductible temporary differences	105	8
Total deferred income tax expense	7	182
Income tax expense included in net earnings	670	2,559

In 2023, we recorded a deferred tax asset of $134 related to an increase in the tax basis of our Swiss assets as a result of changes to our Switzerland tax declarations.

We operate in a specialized industry and in several tax jurisdictions; as a result, our earnings are subject to various rates of taxation.

The provision for income taxes differs from the amount that would have resulted from applying the Canadian statutory income tax rates to earnings before income taxes as follows:

	2023	2022
Earnings (loss) before income taxes		
Canada	1,427	5,707
United States	976	3,447
Australia	161	263
Trinidad	(75)	487
Other	(537)	342
	1,952	10,246
Canadian federal and provincial statutory income tax rate (%)	27	27
Income tax at statutory rates	527	2,766
Adjusted for the effect of:		
Impact of foreign tax rates	(139)	(132)
Swiss Tax Reform adjustment	(134)	–
Non-taxable income	(67)	(98)
Production-related deductions	(54)	(51)
Current year losses for which no deferred tax asset is recognized	314	–
Change in recognition of tax losses and deductible temporary differences	105	8
Tax authority examinations	62	22
Non-deductible expenses	25	16
Withholding taxes	20	18
Other	11	10
Income tax expense included in net earnings	670	2,559

In millions of US dollars unless otherwise noted

Deferred income taxes

	Deferred income tax (assets) liabilities		Deferred income tax (recovery) expense recognized in net earnings	
	2023	2022	2023	2022
Deferred income tax assets				
Asset retirement obligations and accrued environmental costs	(400)	(319)	(17)	35
Tax loss and other carryforwards	(347)	(396)	52	(93)
Lease liabilities	(307)	(298)	(8)	(151)
Inventories	(108)	(155)	47	(30)
Pension and other post-retirement benefit liabilities	(108)	(151)	50	(1)
Long-term debt	(99)	(117)	18	21
Payables and accrued charges	(96)	(98)	2	(84)
Receivables	(50)	(48)	(2)	(4)
Other assets	(1)	(1)	–	–
Deferred income tax liabilities				
Property, plant and equipment	4,410	4,305	40	545
Goodwill and intangible assets	173	347	(168)	(53)
Other liabilities	30	30	(7)	(3)
	3,097	3,099	7	182

Amounts and expiry dates of unused tax losses and unused tax credits as at December 31, 2023, were:

	Amount	Expiry date
Unused federal operating losses	2,056	2024 – Indefinite
Unused federal capital losses	683	Indefinite

The unused tax losses and credits with no expiry dates can be carried forward indefinitely.

As at December 31, 2023, we had $1,532 of federal tax losses for which we did not recognize deferred tax assets.

We have determined that it is probable that all recognized deferred tax assets will be realized through a combination of future reversals of temporary differences and taxable income.

We did not recognize deferred tax liabilities related to temporary differences associated with investments in subsidiaries and equity-accounted investees amounting to $7,010 as at December 31, 2023 (2022 – $13,060).

Note 9 | Net earnings per share

	2023	2022
Weighted average number of common shares	496,381,000	538,475,000
Dilutive effect of stock options	613,000	1,535,000
Weighted average number of diluted common shares	496,994,000	540,010,000

Options excluded from the calculation of diluted net earnings per share due to the option exercise prices being greater than the average market price of common shares were as follows:

	2023	2022
Number of options excluded	821,763	567,409

In millions of US dollars unless otherwise noted

Note 10 | Financial instruments and related risk management

Our ELT, along with the Board of Directors (including Board committees), is responsible for monitoring our risk exposures and managing our policies to address these risks. Our strategic and risk management processes are integrated to ensure we understand the benefit from the relationship between strategy, risk and value creation. Outlined below are our risk management strategies we have developed to mitigate the financial market risks that we are exposed to.

Credit risks	Risk management strategies

Receivables from customers	– establish credit approval policies and procedures for new and existing customers
	– extend credit to qualified customers through
	  – review of credit agency reports, financial statements and/or credit references, as available
	  – review of existing customer accounts every 12 to 24 months based on the credit limit amounts
	  – evaluation of customer and country risk for international customers
	– establish credit period:
	  – 15 and 30 days for wholesale fertilizer customers
	  – 30 days for industrial and feed customers
	  – 30 to 360 days for Retail customers, including Nutrien Financial
	  – up to 180 days for select export sales customers, including Canpotex
	– transact on a cash basis with certain customers who may not meet specified benchmark creditworthiness or cannot provide other evidence of ability to pay
	– execute agency arrangements with financial institutions or other partners with which we have only a limited recourse involvement
	– sell receivables to financial institutions which substantially transfer the risks and rewards
	– set eligibility requirements for Nutrien Financial to limit the risk of the receivables
	– may require security over certain crop or livestock inventories
	– set up provision using the lifetime expected credit loss method considering all possible default events over the expected life of a financial instrument. Receivables are grouped based on days past due and/or customer credit risk profile. Estimated losses on receivables are based on known troubled accounts and historical experience of losses incurred. Receivables are considered to be in default and are written off against the allowance when it is probable that all remaining contractual payments due will not be collected in accordance with the terms of the agreement.

Cash and cash equivalents and other receivables	– require acceptable minimum counterparty credit ratings – limit counterparty or credit exposure – select counterparties with investment-grade quality

Aging of receivables (%) as at December 31:

	2023			2022		
	Retail (Nutrien Financial)	Retail (excluding Nutrien Financial)	Potash, Nitrogen and Phosphate	Retail (Nutrien Financial)	Retail (excluding Nutrien Financial)	Potash, Nitrogen and Phosphate
Current	78	78	89	83	84	97
30 days or less past due	13	6	11	10	9	3
31 – 90 days past due	4	4	–	3	4	–
Greater than 90 days past due	5	12	–	4	3	–
	100	100	100	100	100	100

In millions of US dollars unless otherwise noted

Maximum exposure to credit risk as at December 31:

	2023	2022
Cash and cash equivalents	941	901
Receivables (excluding income tax receivable)	5,103	6,050
	6,044	6,951

Liquidity risk	Risk management strategies
Access to cash	– establish an external borrowing policy to maintain sufficient liquid financial resources to fund our operations and meet our commitments and obligations in a cost-effective manner – maintain an optimal capital structure – maintain investment-grade credit ratings that provide ease of access to the debt capital and commercial paper markets – maintain sufficient short-term credit availability – uphold long-term relationships with a sufficient number of high-quality and diverse lenders – enter into financial arrangements (e.g., Blue Chip Swaps) to remit cash from certain foreign jurisdictions Refer to Note 17 for our available credit facilities.

The following maturity analysis of our financial liabilities and gross settled derivative contracts (for which the cash flows are settled simultaneously) is based on the expected undiscounted contractual cash flows from the date of the consolidated balance sheets to the contractual maturity date.

2023	Carrying amount of liability as at December 31	Contractual cash flows	Within 1 year	1 to 3 years	3 to 5 years	Over 5 years
Short-term debt [1]	1,815	1,815	1,815	–	–	–
Payables and accrued charges [2]	9,024	9,024	9,024	–	–	–
Long-term debt, including current portion [1]	9,425	15,339	966	2,324	1,556	10,493
Lease liabilities, including current portion [1]	1,326	1,525	368	484	222	451
Derivatives	16	16	16	–	–	–
	21,606	27,719	12,189	2,808	1,778	10,944

1 Contractual cash flows include contractual interest payments related to debt obligations and lease liabilities. Interest rates on debt with variable rates are based on the prevailing rates as at December 31, 2023.
2 Excludes non-financial liabilities and includes payables of approximately $2.1 billion related to our prepaid inventory to secure product discounts. We consider these payables to be part of our working capital. For these payables, we participated in arrangements where the vendors sold their right to receive payment to financial institutions without extending the original payment terms. These payables were paid in January 2024.

In millions of US dollars unless otherwise noted

Market risks	Type	Risk management strategies	
Interest rate	Short-term and long-term debt	– use a portfolio of fixed and floating rate instruments – align current and long-term assets with demand and fixed-term debt – monitor the effects of market changes in interest rates – use interest rate swaps, if desired	We do not believe we have material exposure to interest, price or foreign exchange risk on our financial instruments as at December 31, 2023 and 2022.
Price	Natural gas derivative instruments	– diversify our forecast gas volume requirements, including a portion of annual requirements purchased at spot market prices, a portion at fixed prices (up to 10 years) and a portion indexed to the market price of ammonia – acquire a reliable supply of natural gas feedstock and fuel on a location-adjusted, cost-competitive basis and hold firm pipeline transportation to our operating sites	
Price	Investment at fair value	– ensure the security of principal amounts invested – provide for an adequate degree of liquidity – achieve a satisfactory return	
Foreign exchange		– execute foreign currency derivative contracts within certain prescribed limits for both actual and forecasted expenditures to manage the impact to cash flows and earnings, including those related to our equity-accounted investees, that could occur from a reasonably possible strengthening or weakening of the US dollar	

The fair value of our net foreign exchange currency derivative assets (liabilities) as at December 31, 2023 was $11 (2022 – $(18)). The following table presents the significant foreign currency derivatives that existed as at December 31:

	2023			2022		
Sell/buy	**Notional**	**Maturities**	**Average contract rate**	**Notional**	**Maturities**	**Average contract rate**
Derivatives not designated as hedges						
Forwards						
USD/Canadian dollars ("CAD")	435	2024	1.3207	473	2023	1.3584
Australian dollars/USD	86	2024	1.5269	133	2023	1.5010
Brazilian real/USD	94	2024	4.8688	374	2023	5.6892
Derivatives designated as hedges						
Forwards						
USD/CAD	601	2024	1.3565	487	2023	1.3255

In millions of US dollars unless otherwise noted

Fair value

Financial instruments included in the consolidated balance sheets are measured either at fair value or amortized cost.

Financial instruments at fair value	Fair value method and associated level within the fair value hierarchy
Cash and cash equivalents	Carrying amount (approximation to fair value assumed due to short-term nature)
Equity securities	Closing bid price of the common shares (Level 1) as at the balance sheet date
Debt securities	Closing bid price of the debt or other instruments with similar terms and credit risk (Level 2) as at the balance sheet date
Foreign currency derivatives not traded in an active market	Quoted forward exchange rates (Level 2) as at the balance sheet date
Foreign exchange forward contracts, swaps and options, and natural gas swaps not traded in an active market	Based on a discounted cash flow ("DCF") model. Inputs included contractual cash flows based on prices for natural gas futures contracts, fixed prices and notional volumes specified by the swap contracts, the time value of money, liquidity risk, our own credit risk (related to instruments in a liability position) and counterparty credit risk (related to instruments in an asset position). Futures contract prices used as inputs in the model were supported by prices quoted in an active market and therefore categorized in Level 2.

Financial instruments at amortized cost	Fair value method
Receivables, short-term debt, and payables and accrued charges	Carrying amount (approximation to fair value assumed due to short-term nature)
Long-term debt	Quoted market prices (Level 1 or 2 depending on the market liquidity of the debt)
Other long-term debt instruments	Carrying amount (approximation to fair value)

The following table presents our fair value hierarchy for financial instruments carried at fair value on a recurring basis or measured at amortized cost and require fair value disclosure. The table does not include fair value information for financial instruments that are measured using their carrying amount as a reasonable approximation of fair value.

	2023				2022			
Financial assets (liabilities) measured at	Carrying amount	Level 1	Level 2	Level 3	Carrying amount	Level 1	Level 2	Level 3
Fair value on a recurring basis [1]								
Derivative instrument assets	20	–	20	–	7	–	7	–
Other current financial assets – marketable securities [2]	173	35	138	–	148	19	129	–
Investments at fair value through other comprehensive income ("FVTOCI") (Note 15)	190	180	–	10	200	190	–	10
Investments at fair value through profit or loss ("FVTPL") (Note 15)	45	–	–	45	44	–	–	44
Derivative instrument liabilities	(16)	–	(16)	–	(35)	–	(35)	–
Amortized cost								
Investments at amortized cost (Note 15)	19	16	–	–	–	–	–	–
Current portion of long-term debt								
Senior notes and debentures	(499)	–	(502)	–	(500)	(493)	–	–
Fixed and floating rate debt	(13)	–	(13)	–	(42)	–	(42)	–
Long-term debt								
Senior notes and debentures	(8,884)	(3,110)	(5,462)	–	(7,910)	(3,581)	(3,656)	–
Fixed and floating rate debt	(29)	–	(29)	–	(130)	–	(130)	–

1 During 2023 and 2022, there were no transfers between levels for financial instruments measured at fair value on a recurring basis. Our policy is to recognize transfers at the end of the reporting period.
2 Marketable securities consist of equity and debt securities.

In millions of US dollars unless otherwise noted

Note 11 | Receivables

	Segment	2023	2022
Receivables from customers			
Third parties	Retail (Nutrien Financial) [1]	2,943	2,705
	Retail	1,097	1,293
	Potash, Nitrogen, Phosphate	577	827
Related party – Canpotex	Potash (Note 28)	162	866
Less allowance for expected credit losses of receivables from customers		(111)	(95)
		4,668	5,596
Rebates		198	172
Income taxes (Note 8)		295	144
Other receivables		237	282
		5,398	6,194

1 Includes $2,578 of very low risk of default and $365 of low risk of default (2022 – $2,260 of very low risk of default and $445 of low risk of default).

Qualifying receivables from customers financed by Nutrien Financial represent high-quality receivables from customers that have been rated very low to low risk of default among Retail's receivables from customers.

Customer credit with a financial institution of $431 as at December 31, 2023, related to our agency agreement, is not recognized in our consolidated balance sheets. Through the agency agreement, we only have a limited recourse involvement to the extent of an indemnification of the financial institution to a maximum of 5 percent (2022 – 5 percent) of the qualified customer loans. Historical indemnification losses on this arrangement have been negligible, and the average aging of the customer loans with the financial institution is current.

Note 12 | Inventories

	2023	2022
Product purchased for resale	4,941	5,885
Finished products	351	612
Intermediate products	160	184
Raw materials	299	425
Materials and supplies	585	526
	6,336	7,632

By segment	2023	2022
Retail	5,041	6,035
Potash	371	398
Nitrogen	493	706
Phosphate	431	493
	6,336	7,632

Inventories expensed to cost of goods sold during the year were $19,391 (2022 – $21,371).

In millions of US dollars unless otherwise noted

Note 13 | Property, plant and equipment

	Land and improvements	Buildings and improvements	Machinery and equipment	Mine development costs	Assets under construction	Total
Useful life range (years)	1 – 85	1 – 70	1 – 80	1 – 60	n/a	
Carrying amount – December 31, 2022	1,201	6,340	11,017	1,108	2,101	21,767
Acquisitions (Note 25)	–	2	5	–	–	7
Additions	1	5	37	–	2,422	2,465
Additions – Right-of-use ("ROU") assets	1	70	338	–	–	409
Disposals	(6)	(7)	(37)	–	(1)	(51)
Transfers	26	188	1,401	237	(1,852)	–
Foreign currency translation and other	12	32	94	3	(165)	(24)
Depreciation	(39)	(184)	(1,054)	(138)	–	(1,415)
Depreciation – ROU assets	(2)	(60)	(326)	–	–	(388)
Impairment	(19)	(10)	(148)	(95)	(37)	(309)
Carrying amount – December 31, 2023	1,175	6,376	11,327	1,115	2,468	22,461
Balance – December 31, 2023 is composed of:						
Cost	1,631	9,050	23,237	2,938	2,468	39,324
Accumulated depreciation and impairments	(456)	(2,674)	(11,910)	(1,823)	–	(16,863)
Carrying amount – December 31, 2023	1,175	6,376	11,327	1,115	2,468	22,461
Balance – December 31, 2023 is composed of:						
Owned property, plant and equipment	1,145	5,980	10,486	1,115	2,468	21,194
ROU assets	30	396	841	–	–	1,267
Carrying amount – December 31, 2023	1,175	6,376	11,327	1,115	2,468	22,461
Carrying amount – December 31, 2021	1,073	6,305	10,221	853	1,564	20,016
Acquisitions (Note 25)	12	40	23	–	65	140
Additions	17	9	25	–	2,202	2,253
Additions – ROU assets	–	51	230	–	–	281
Disposals	(9)	(13)	(24)	–	–	(46)
Transfers	35	163	1,281	170	(1,649)	–
Foreign currency translation and other	5	2	55	30	(90)	2
Depreciation	(35)	(185)	(1,006)	(94)	–	(1,320)
Depreciation – ROU assets	(2)	(58)	(279)	–	–	(339)
Reversal of impairment	105	26	491	149	9	780
Carrying amount – December 31, 2022	1,201	6,340	11,017	1,108	2,101	21,767
Balance – December 31, 2022 is composed of:						
Cost	1,605	8,795	22,023	2,699	2,101	37,223
Accumulated depreciation and impairments	(404)	(2,455)	(11,006)	(1,591)	–	(15,456)
Carrying amount – December 31, 2022	1,201	6,340	11,017	1,108	2,101	21,767
Balance – December 31, 2022 is composed of:						
Owned property, plant and equipment	1,173	5,956	10,267	1,108	2,101	20,605
ROU assets	28	384	750	–	–	1,162
Carrying amount – December 31, 2022	1,201	6,340	11,017	1,108	2,101	21,767

In millions of US dollars unless otherwise noted

Depreciation of property, plant and equipment was included in the following:

	2023	2022
Freight, transportation and distribution	165	148
Cost of goods sold	1,157	1,024
Selling expenses	453	424
General and administrative expenses	48	42
Depreciation recorded in earnings	1,823	1,638
Depreciation recorded in inventory	145	151

Impairments and impairment reversals

For each cash generating unit ("CGU") or groups of CGUs in which we complete an impairment analysis, the recoverable amount estimate used the following key assumptions: our forecasted EBITDA, discount rate and long-term growth rate. For our Phosphate CGUs, we also estimate the end of expected mine life. We used key assumptions that were based on historical data and estimates of future results from internal sources, independent third-party price benchmarks, and mineral reserve technical reports (relating to Phosphate CGUs), as well as industry and market information.

Phosphate

In 2023, we identified an impairment trigger for our Phosphate CGUs, White Springs and Aurora, primarily as a result of the decrease in our forecasted phosphate margins. We completed our impairment analysis for these CGUs.

Phosphate CGU	White Springs	Aurora
Impairment assessment date	June 30, 2023	June 30, 2023
Recoverable amount ($)	504	2,000
Carrying amount before impairment loss ($)	737	1,660
Pre-tax impairment loss ($)	233	–
Valuation methodology	Value in use ("VIU")	Fair value less costs of disposal ("FVLCD"), a Level 3 measurement
Valuation technique	Pre-tax DCF to end of expected mine life	Five-year DCF plus terminal year to end of mine life

In 2022, we completed an impairment analysis at our White Springs and Aurora CGUs as a result of revised pricing forecasts to reflect the macroeconomic environment at the time. We completed our impairment analysis for these CGUs.

Phosphate CGU	White Springs	Aurora
Impairment reversal date	September 30, 2022	June 30, 2022
Recoverable amount ($)	770	2,900
Carrying amount before impairment reversal ($)	425	1,200
Pre-tax impairment reversal (net of depreciation) ($) [1]	330	450
Valuation methodology	VIU	FVLCD
Valuation technique	Pre-tax DCF to end of expected mine life	Five-year DCF plus terminal year to end of mine life

1 Full reversal of the previously recorded impairment losses relating to property, plant and equipment at White Springs in 2017 and 2020 of $250 and $215, respectively, and Aurora in 2020 of $545.

In millions of US dollars unless otherwise noted

Key assumptions [1]	White Springs 2023	White Springs 2022	Aurora 2022
End of mine life (proven and probable reserves) (year) [2]	2032	2030	2050
Long-term growth rate (%)	n/a	n/a	2.0
Pre-tax discount rate (%)	15.6	15.2	n/a
Post-tax discount rate (%)	12.0	12.0	10.4
Forecasted EBITDA [3] ($)	720	980	3,090

1 At impairment loss (reversal) date.
2 The White Springs CGU has a shorter expected mine life and is therefore more sensitive to changes in short- and medium-term forecasted phosphate margins.
3 Forecasted EBITDA to 2028 (2022 – Forecasted EBITDA to 2027).

Sensitivities

The following table highlights sensitivities to the recoverable amounts of our Phosphate CGUs, which could result in additional impairment losses or reversals of the previously recorded losses (relating to the White Springs CGU).

Key assumptions as at June 30, 2023	Change in assumption	Change to recoverable amount ($) White Springs		Aurora	
Long-term growth rate (%)	+ / - 1.0 percent	n/a	n/a	+ / -	110
Pre-tax discount rate (%)	+ / - 1.0 percent	- / +	20	n/a	n/a
Post-tax discount rate (%)	+ / - 1.0 percent	n/a	n/a	- / +	190
Forecasted EBITDA over forecast period ($)	+ / - 5.0 percent	+ / -	40	+ / -	220

Nitrogen

In 2023, we identified an impairment trigger for our Trinidad CGU, part of our Nitrogen segment, due to a new natural gas contract and the resulting outlook for higher expected natural gas costs and constrained near-term availability. We expect improved natural gas availability in Trinidad as the development of additional natural gas fields is anticipated to add new natural gas supply starting in 2026.

December 31, 2023	Trinidad
Recoverable amount ($)	676
Carrying amount before impairment loss ($)	752
Pre-tax impairment loss ($)	76
Valuation methodology	FVLCD, a Level 3 measurement
Valuation technique	Five-year DCF plus a terminal value
Key assumptions	
Long-term growth rate (%)	2.3
Post-tax discount rate [1] (%)	13.0
Forecasted EBITDA [2,3] ($)	1,145

1 Discount rate used in the previous measurement in 2020 was 12.6 percent.
2 First five years of the forecast period.
3 Includes key assumptions relating to net selling price based on forecasted future natural gas contracting and availability.

Sensitivities

The following table highlights sensitivities to the recoverable amount of our Trinidad CGU, which could result in additional impairment losses or reversals of the previously recorded losses.

Key assumptions as at December 31, 2023	Change in assumption	Change to recoverable amount ($)	
Long-term growth rate (%)	+ / - 1.0 percent	+ / -	55
Post-tax discount rate (%)	+ / - 1.0 percent	- / +	95
Forecasted EBITDA over forecast period ($)	+ / - 5.0 percent	+ / -	100

In millions of US dollars unless otherwise noted

Note 14 | Goodwill and intangible assets

	Goodwill	Intangible assets: Customer relationships [1]	Technology	Trade names	Other	Total
Useful life range (years)	n/a	5 – 15	2 – 20	3 – 15 [2]	1 – 30	
Carrying amount – December 31, 2022	12,368	1,229	702	95	271	2,297
Acquisitions (Note 25)	126	30	–	7	1	38
Additions – internally developed	–	–	206	–	–	206
Foreign currency translation and other	42	9	49	4	(1)	61
Amortization [3]	–	(164)	(114)	(8)	(56)	(342)
Impairment	(422)	(43)	–	–	–	(43)
Carrying amount – December 31, 2023	12,114	1,061	843	98	215	2,217
Balance – December 31, 2023 is composed of:						
Cost	12,542	2,046	1,263	160	656	4,125
Accumulated amortization and impairment	(428)	(985)	(420)	(62)	(441)	(1,908)
Carrying amount – December 31, 2023	12,114	1,061	843	98	215	2,217
Carrying amount – December 31, 2021	12,220	1,350	595	80	315	2,340
Acquisitions (Note 25)	200	59	–	22	23	104
Additions – internally developed	–	–	216	–	6	222
Foreign currency translation and other	(52)	(13)	14	1	(1)	1
Disposals	–	(1)	(1)	–	–	(2)
Amortization [3]	–	(166)	(122)	(8)	(72)	(368)
Carrying amount – December 31, 2022	12,368	1,229	702	95	271	2,297
Balance – December 31, 2022 is composed of:						
Cost	12,375	2,001	1,028	150	649	3,828
Accumulated amortization and impairment	(7)	(772)	(326)	(55)	(378)	(1,531)
Carrying amount – December 31, 2022	12,368	1,229	702	95	271	2,297

1 The average remaining amortization period of customer relationships as at December 31, 2023, was approximately 3 years.
2 Certain trade names have indefinite useful lives as there are no regulatory, legal, contractual, cooperative, economic or other factors that limit their useful lives.
3 Amortization of $279 was included in selling expenses during the year ended December 31, 2023 (2022 – $302).

Goodwill impairment testing

Goodwill by CGU or group of CGUs	2023	2022
Retail – North America	6,981	6,898
Retail – International [1]	590	927
Potash	154	154
Nitrogen	4,389	4,389
	12,114	12,368

1 Includes Retail – South America group of CGUs, which had goodwill of nil as at December 31, 2023 (2022 – $348).

In millions of US dollars unless otherwise noted

In testing for impairment of goodwill, we calculate the recoverable amount for a CGU or groups of CGUs containing goodwill. We used the FVLCD methodology based on after-tax discounted cash flows (five-year projections plus a terminal value with the exception of the Retail – South America group of CGUs, which used a 10-year projection plus a terminal value) and incorporated assumptions an independent market participant would apply, including considerations related to climate-change initiatives. We adjusted discount rates for each CGU or group of CGUs for the risk associated with achieving our forecasts and for the country risk premium in which we expect to generate cash flows. FVLCD is a Level 3 measurement. We use our market capitalization (where applicable) and comparative market multiples to ensure discounted cash flow results are reasonable.

The key assumptions with the greatest influence on the calculation of the recoverable amounts are the discount rates, terminal growth rates and forecasted EBITDA. The key forecast assumptions were based on historical data and our estimates of future results from internal sources considering industry and market information.

In 2023, we revised our forecasted EBITDA for the Retail – South America group of CGUs, which triggered an impairment analysis. Due to the impact of crop input price volatility, more moderate long-term growth assumptions and higher interest rates, we lowered our product margin expectations and deferred certain of our planned strategic investments. As a result, this reduced our forecasted EBITDA and growth. Therefore, we recorded the following impairment:

Retail – South America group of CGUs	**June 30, 2023**
Recoverable amount	1,031
Carrying amount before impairment loss	1,496
Impairment recognized relating to:	
Goodwill	422
Intangible assets	43

The following table highlights sensitivities to the Retail – South America group of CGUs recoverable amount, which could have resulted in additional impairment against the carrying amount of intangible assets and property, plant and equipment.

Key assumptions as at June 30, 2023	**Key assumption**	**Change in key assumption**	**Decrease to recoverable amount ($)**
Terminal growth rate (%)	6.0	- 1.0 percent	50
Discount rate (%)	16.6	+ 1.0 percent	120
Forecasted EBITDA over forecast period ($)	4,300	- 5.0 percent	100

1 The discount rate used in the previous measurement was 16.0 percent, which was included as part of our Retail – International group of CGUs.

We performed our annual impairment test on goodwill on the remaining CGUs or group of CGUs and did not identify any further impairment; however, the recoverable amount for the Retail – North America group of CGUs did not substantially exceed its carrying amount. The Retail – North America group of CGUs recoverable amount exceeds its carrying amount by $570. Goodwill is more susceptible to impairment risk if there is an increase in the discount rate or a deterioration in business operating results or economic conditions and actual results do not meet our forecasts. A reduction in the terminal growth rate, an increase in the discount rate or a decrease in forecasted EBITDA could cause impairment in the future as shown in the table below.

2023 Annual impairment testing	**Key assumption used in impairment model**	**Change required for carrying amount to equal recoverable amount**
Terminal growth rate (%)	2.5	0.4 percent decrease
Discount rate[1] (%)	8.6	0.2 percent increase
Forecasted EBITDA over forecast period ($)	8,040	3.0 percent decrease

1 The discount rate used in the previous measurement was 8.5 percent.

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The following table indicates the key assumptions used in testing the remaining groups of CGUs:

	Terminal growth rate (%)		Discount rate (%)	
	2023	2022	2023	2022
Retail – International [1]	2.1	2.0 – 6.0	9.0	8.9 – 16.0
Potash	2.5	2.5	7.6	8.3
Nitrogen	2.3	2.0	8.3	9.3

1 The discount rates reflect the country risk premium and size for our international groups of CGUs. The terminal growth rate and discount rate ranges in 2022 included our Retail – South America group of CGUs, which are no longer included in 2023 as goodwill for this group of CGUs is nil.

Note 15 | Investments

Name	Principal activity	Principal place of business and incorporation	Proportion of ownership interest and voting rights held (%) 2023	2022	Carrying amount 2023	2022 [1]
Equity-accounted investees						
Profertil	Nitrogen producer	Argentina	50	50	340	450
Canpotex	Marketing and logistics of potash	Canada	50	50	–	–
Other associates and joint ventures					142	149
Total equity-accounted investees					482	599
Investments at FVTOCI						
Sinofert	Fertilizer supplier and distributor	China/Bermuda	22	22	180	190
Other					10	10
Total investments at FVTOCI					190	200
Investments at FVTPL						
Other					45	44
Total investments at FVTPL					45	44
Investments at amortized cost						
Other					19	–
Total investments at amortized cost					19	–
Total investments					736	843

1 Certain immaterial 2022 figures have been reclassified.

In millions of US dollars unless otherwise noted

We continuously assess our ability to exercise significant influence or joint control over our investments. Our 22 percent ownership in Sinofert does not constitute significant influence as we do not have any representation on the board of directors of Sinofert. We elected to account for our investment in Sinofert as FVTOCI as it is held for strategic purposes.

Summarized financial information of Profertil[1] **For the years ended December 31**	**2023**	**2022**
Sales	762	1,096
Depreciation and amortization	5	5
Interest expense	10	4
Interest income	170	136
Income tax expense	166	277
Net earnings and total comprehensive income	178	466
Proportionate share of Profertil earnings	89	233
Elimination of unrealized profit	1	–
Total proportionate share of Profertil earnings	90	233
Dividends received from Profertil	199	57

As at December 31	**2023**	**2022**
Current assets[2]	355	835
Non-current assets	658	589
	1,013	1,424
Current liabilities[3]	143	297
Non-current liabilities[4]	186	221
	329	518
Net assets of Profertil	684	906
Proportionate share of net assets of Profertil	342	453
Elimination of unrealized profit	(2)	(3)
Carrying amount of interest in Profertil	340	450

1 Summarized financial information of Profertil, which represents the amounts included in its own financial statements, adjusted for fair value adjustments at acquisition and differences in accounting policies.
2 Includes cash and cash equivalents of $204 (2022 – $585).
3 Includes current financial liabilities (excluding trade and other payables and provisions) of $21 (2022 – $27).
4 Includes non-current financial liabilities (excluding trade and other payables and provisions) of nil (2022 – $23).

Future conditions related to Profertil may be affected by political, economic and social instability. We are exposed to foreign exchange risk related to fluctuations in the Argentine peso against the US dollar and currency controls, which may restrict our ability to repatriate dividends from Profertil.

In millions of US dollars unless otherwise noted

Note 16 | Other assets

	2023	2022
Deferred income tax assets (Note 8)	477	448
Ammonia catalysts [1]	113	104
Long-term income tax receivable (Note 8)	91	54
Accrued pension benefit assets (Note 21)	138	157
Other	232	206
	1,051	969

1 Net of accumulated amortization of $99 (2022 – $94).

Note 17 | Short-term debt

	Rate of interest (%)	2023	2022
Credit facilities			
Unsecured revolving term credit facility	n/a	–	500
Other unsecured credit facilities			
South America [1]	5.5 – 12.2	219	453
Australia	5.3	221	190
Other	4.8	21	9
Commercial paper [2]	5.5 – 5.9	1,175	783
Other short-term debt		179	207
		1,815	2,142

1 Our credit facilities are either denominated in local currency or US dollars. The range of interest rates for South America excludes our Argentina facilities denominated in local currency with interest rates ranging from 102.5 percent to 107.0 percent. The balance of these Argentina facilities as at December 31, 2023 was $18.
2 We use our $4,500 commercial paper program for our short-term cash requirements. The amount available under the commercial paper program is limited to the availability of backup funds under the $4,500 unsecured revolving term credit facility and excess cash invested in highly liquid securities.

Credit facility limits [1]	As at December 31, 2023
Unsecured revolving term facility [2]	4,500
Unsecured revolving term facility [3]	1,500
Uncommitted revolving demand facility	1,000
Other credit facilities [4]	1,320

1 Our credit facilities are renegotiated periodically.
2 Matures September 14, 2027, subject to extension at the request of Nutrien provided that the resulting maturity date may not exceed five years from the date of request.
3 In 2023, we extended the term of our unsecured revolving term credit facility to September 10, 2024 and reduced the facility limit from $2,000 to $1,500.
4 Total facility limit amounts include some facilities with maturities in excess of one year.

Principal covenants and events of default under the unsecured revolving term credit facilities include a debt to capital ratio (refer to Note 24) and other customary events of default and covenant provisions. Non-compliance with such covenants could result in accelerated repayment and/or termination of the credit facility. We were in compliance with all covenants as at December 31, 2023.

In millions of US dollars unless otherwise noted

Note 18 | Long-term debt

	Rate of interest (%)	Maturity	2023	2022
Senior notes[1]				
	1.900	May 13, 2023	–	500
	5.900	November 7, 2024	500	500
	3.000	April 1, 2025	500	500
	5.950	November 7, 2025	500	500
	4.000	December 15, 2026	500	500
	4.900	March 27, 2028	750	–
	4.200	April 1, 2029	750	750
	2.950	May 13, 2030	500	500
	4.125	March 15, 2035	450	450
	7.125	May 23, 2036	212	212
	5.875	December 1, 2036	500	500
	5.625	December 1, 2040	500	500
	6.125	January 15, 2041	401	401
	4.900	June 1, 2043	500	500
	5.250	January 15, 2045	489	489
	5.000	April 1, 2049	750	750
	3.950	May 13, 2050	500	500
	5.800	March 27, 2053	750	–
Debentures[1]	7.800	February 1, 2027	120	120
Other credit facilities[2]	Various	Various	42	165
Other long-term debt	n/a	Various	–	7
			9,214	8,344
Add net unamortized fair value adjustments			294	310
Less net unamortized debt issue costs			(83)	(72)
			9,425	8,582
Less current maturities			(512)	(542)
			8,913	8,040

1 Each series of senior notes and debentures is unsecured and has no sinking fund requirements prior to maturity. Each series is redeemable and has various provisions that allow redemption prior to maturity, at our option, at specified prices.
2 Other credit facilities are unsecured and consist of South America facilities with debt of $40 (2022 – $162) and an interest rate of 2.3 percent and other facilities with debt of $2 (2022 – $3) and an interest rate of 4.0 percent.

We are subject to certain customary covenants including limitation on liens, merger and change of control covenants, and customary events of default. As calculated in Note 24, we were in compliance with these covenants as at December 31, 2023.

In millions of US dollars unless otherwise noted

The following is a summary of changes in liabilities arising from financing activities:

	Short-term debt	Long-term debt	Lease liabilities	Total
Balance – December 31, 2022	2,142	8,582	1,204	11,928
Cash flows (cash inflows and outflows presented on a net basis)	(458)	832	(375)	(1)
Additions and other adjustments to ROU liabilities	–	–	492	492
Foreign currency translation and other non-cash changes	131	11	5	147
Balance – December 31, 2023	1,815	9,425	1,326	12,566
Balance – December 31, 2021	1,560	8,066	1,220	10,846
Cash flows (cash inflows and outflows presented on a net basis)	529	475	(341)	663
Additions and other adjustments to ROU liabilities	–	–	334	334
Foreign currency translation and other non-cash changes	53	41	(9)	85
Balance – December 31, 2022	2,142	8,582	1,204	11,928

Note 19 | Lease liabilities

	Average rate of interest (%)	2023	2022
Lease liabilities – non-current	4.3	999	899
Current portion of lease liabilities	4.5	327	305
Total		1,326	1,204

Note 20 | Payables and accrued charges

	2023	2022
Trade and other payables [1]	5,477	5,797
Customer prepayments	2,084	2,298
Dividends	262	244
Accrued compensation	597	681
Current portion of asset retirement obligations and accrued environmental costs (Note 22)	165	234
Accrued interest	117	102
Current portion of share-based compensation (Note 5)	32	142
Current portion of derivatives	16	35
Income taxes (Note 8)	14	899
Provincial mining taxes	1	114
Other taxes	62	59
Current portion of pension and other post-retirement benefits (Note 21)	15	15
Other accrued charges and others	625	671
	9,467	11,291

1 Includes amounts owing to Canpotex (Note 28) of $64 (2022 – $203).

In millions of US dollars unless otherwise noted

Note 21 | Pension and other post-retirement benefits

We offer the following pension and other post-retirement benefits to qualified employees: defined benefit pension plans; defined contribution pension plans; and health, dental and life insurance, referred to as other post-retirement plans. Substantially all our employees participate in at least one of these plans.

Description of defined benefit pension plans

	Plan type	Contributions
United States	– non-contributory, – guaranteed annual pension payments for life, – benefits generally depend on years of service and compensation level in the final years leading up to age 65, – benefits available starting at age 55 at a reduced rate, and – plans provide for maximum pensionable salary and maximum annual benefit limits.	– made to meet or exceed minimum funding requirements of the Employee Retirement Income Security Act of 1974 and associated Internal Revenue Service regulations and procedures.
Canada		– made to meet or exceed minimum funding requirements based on provincial statutory requirements and associated federal taxation rules.
Supplemental plans in US and Canada for Senior Management	– non-contributory, – unfunded, and – supplementary pension benefits.	– provided for by charges to earnings sufficient to meet the projected benefit obligations, and – payments to plans are made as plan payments to retirees occur.

Our defined benefit pension plans are funded with separate funds that are legally separated from the Company and administered through the Pension Committee in each country, which is composed of our employees. The Pension Committee is required by law to act in the best interests of the plan participants and, in the US and Canada, is responsible for the governance of the plans, including setting certain policies (e.g., investment and contribution) of the funds. The current investment policy for each country's plans generally does not include currency hedging strategies. Plan assets held in trusts are governed by local regulations and practices in each country, as is the nature of the relationship between the Company and the trustees and their composition.

Description of other post-retirement plans

We provide health care plans for certain eligible retired employees in the US, Canada and Trinidad. Eligibility for these benefits is generally based on a combination of age and years of service at retirement. Certain terms of the plans include

- coordination with government-provided medical insurance in each country;
- certain unfunded cost-sharing features such as co-insurance, deductibles and co-payments – benefits subject to change;
- for certain plans, maximum lifetime benefits;
- at retirement, the employee's spouse and certain dependent children may be eligible for coverage;
- benefits are self-insured and are administered through third-party providers; and
- generally, retirees contribute towards annual cost of the plans.

In addition, certain Medicare eligible retired employees in the US receive an annual contribution to a Healthcare Reimbursement Account, which can be used to purchase health benefits through a private exchange. This annual contribution can be used for premiums or to pay deductibles and/or co-insurance. Finally, we provide non-contributory life insurance plans for certain retired employees who meet specific age and service eligibility requirements.

Risks

The defined benefit pension and other post-retirement plans expose us to broadly similar actuarial risks. The most significant risks include investment risk and interest rate risk as discussed below. Other risks include longevity risk.

Investment risk	A deficit will be created if plan assets underperform the discount rate used in the defined benefit obligation valuation. To mitigate investment risk, we employ – a diversified mix of return seeking and liability hedging (i.e., fixed income) investments; and – a risk tolerance established through careful consideration of plan liabilities, plan funded status and corporate financial condition. Investment risk is measured and monitored on an ongoing basis through quarterly investment portfolio reviews, annual liability measurements and periodic asset/liability studies.
Interest rate risk	A decrease in bond interest rates will increase the pension liability; however, this is generally expected to be partially offset by an increase in the return on the plan's debt investments.

Financial information

	2023			2022		
	Obligation	Plan assets	Net	Obligation	Plan assets	Net
Balance – beginning of year	(1,507)	1,330	(177)	(1,996)	1,731	(265)
Components of defined benefit expense recognized in earnings						
Current service cost for benefits earned during the year	(16)	–	(16)	(27)	–	(27)
Interest (expense) income	(70)	65	(5)	(60)	52	(8)
Past service cost, including curtailment gains and settlements [1]	76	–	76	24	(39)	(15)
Foreign exchange rate changes and other	(8)	4	(4)	28	(21)	7
Subtotal of components of defined benefit (recovery) expense recognized in earnings	(18)	69	51	(35)	(8)	(43)
Remeasurements of the net defined benefit liability recognized in OCI during the year						
Actuarial gain arising from:						
Changes in financial assumptions	7	–	7	423	–	423
Changes in demographic assumptions	–	–	–	21	–	21
(Loss) gain on plan assets (excluding amounts included in net interest)	–	(30)	(30)	–	(337)	(337)
Subtotal of remeasurements	7	(30)	(23)	444	(337)	107
Cash flows						
Contributions by plan participants	(4)	4	–	(6)	6	–
Employer contributions	–	20	20	–	24	24
Benefits paid	83	(83)	–	86	(86)	–
Subtotal of cash flows	79	(59)	20	80	(56)	24
Balance – end of year [2]	(1,439)	1,310	(129)	(1,507)	1,330	(177)
Balance is composed of:						
Non-current assets						
Other assets (Note 16)			138			157
Current liabilities						
Payables and accrued charges (Note 20)			(15)			(15)
Non-current liabilities						
Pension and other post-retirement benefit liabilities			(252)			(319)

1 In 2023, there were design plan changes that resulted in a gain of $80 to other post-retirement pension plans.
2 Obligations arising from funded and unfunded pension plans are $1,266 and $173 (2022 – $1,255 and $252), respectively. Other post-retirement benefit plans have no plan assets and are unfunded.

In millions of US dollars unless otherwise noted APPX ATT_V3_1516 Nutrien Annual Report 2023 127

Plan assets

As at December 31, the fair value of plan assets of our defined benefit pension plans, by asset category, were as follows:

	2023			2022		
	Quoted prices in active markets for identical assets	Other[1]	Total	Quoted prices in active markets for identical assets	Other[1]	Total
Cash and cash equivalents	30	5	35	93	4	97
Equity securities and equity funds						
US	9	115	124	8	107	115
International	–	9	9	–	14	14
Debt securities[2]	–	909	909	–	841	841
Other	–	233	233	–	263	263
Total pension plan assets	39	1,271	1,310	101	1,229	1,330

1 Approximately 96 percent (2022 – 100 percent) of the Other plan assets are held in funds whose fair values are estimated using their net asset value per share. For the majority of these funds, the redemption frequency is immediate. The Pension Committee manages the asset allocation based upon our current liquidity and income needs.
2 Debt securities included US securities of 76 percent (2022 – 77 percent), International securities of 20 percent (2022 – 22 percent) and Mortgage-backed securities of 4 percent (2022 – 1 percent).

We use letters of credit or surety bonds to secure certain Canadian unfunded defined benefit plan liabilities as at December 31, 2023.

We expect to contribute approximately $140 to all pension and post-retirement plans in 2024. Total contributions recognized as expense under all defined contribution plans for 2023 was $139 (2022 – $128).

We used the following significant assumptions to determine the benefit obligations and expense for our significant plans as at and for the year ended December 31. These assumptions are determined by management and are reviewed annually by our independent actuaries.

	Pension		Other	
	2023	2022	2023	2022
Assumptions used to determine the benefit obligations[1]:				
Discount rate (%)	5.03	5.01	4.81	4.86
Rate of increase in compensation levels (%)	4.28	4.29	n/a	n/a
Medical cost trend rate – assumed (%)[2]	n/a	n/a	4.50 – 6.75	4.50 – 7.00
Medical cost trend rate – year reaches ultimate trend rate	n/a	n/a	2033	2033
Mortality assumptions (years)[3]				
Life expectancy at 65 for a male member currently at age 65	20.7	20.6	21.0	20.5
Life expectancy at 65 for a female member currently at age 65	22.9	22.9	23.6	23.2
Average duration of the defined benefit obligations (years)[4]	12.3	12.7	10.6	12.8

1 The current year's expense is determined using the assumptions that existed at the end of the previous year.
2 We assumed a graded medical cost trend rate starting at 6.75 percent in 2023, moving to 4.50 percent by 2033 (2022 – starting at 7.00 percent, moving to 4.50 percent by 2033). The annual health care reimbursement amount is assumed to increase by 2.00 percent each year.
3 Based on actuarial advice in accordance with the latest available published tables, adjusted where appropriate to reflect future longevity improvements for each country.
4 Weighted average length of the underlying cash flows.

Of the most significant assumptions, a change in discount rates has the greatest potential impact on our pension and other post-retirement benefit plans, with sensitivity to change as follows:

	Change in assumption	2023	2022
Benefit obligation as reported		1,439	1,507
Discount rate	1.0 percentage point decrease	190	210
	1.0 percentage point increase	(150)	(170)

In millions of US dollars unless otherwise noted

Note 22 | Asset retirement obligations and accrued environmental costs

December 31, 2023	Cash flow payments (years)[1]	Discounted cash flows[2,3]	Discount rate +0.5%	Discount rate -0.5%
Asset retirement obligations			(70)	90
Retail	1 – 30	16		
Potash	28 – 484	117		
Phosphate	1 – 77	479		
Corporate and others[4,5]	1 – 69	647		
Accrued environmental costs			(5)	5
Retail	1 – 30	69		
Corporate and others	1 – 15	326		
Total		1,654		

1 Time frame in which payments are expected to principally occur from December 31, 2023. Adjustments to the years can result from changes to the mine life and/or changes in the rate of tailings volumes.
2 Risk-free discount rates used to discount cash flows reflect current market assessments of the time value of money and the risks specific to the timing and jurisdiction of the obligation. Risk-free discount rates range from 3.1 percent to 5.5 percent.
3 Total undiscounted cash flows are $5.0 billion. For the Potash segment, this represents total undiscounted cash flows in the first year of decommissioning. This excludes subsequent years of tailings dissolution, fine tails capping, tailings management area reclamation, post-reclamation activities and monitoring, and final decommissioning, which are estimated to take an additional 124 to 456 years.
4 For nitrogen sites, there are no significant asset retirement obligations recorded as there is no reasonable basis for estimating a date or range of dates of cessation of operations. We considered the historical performance of our facilities as well as our planned maintenance, major upgrades and replacements, which can extend the useful lives of our facilities indefinitely.
5 Includes certain potash and phosphate sites that are non-operating sites, with the majority of phosphate site payments taking place over the next 16 years.

	Asset retirement obligations	Accrued environmental costs	Total
Balance – December 31, 2022	1,187	450	1,637
Disposals	–	(2)	(2)
Change in estimate (Note 6)	129	15	144
Settlements	(94)	(68)	(162)
Accretion	32	1	33
Foreign currency translation and other	5	(1)	4
Balance – December 31, 2023	1,259	395	1,654
Balance – December 31, 2023 is composed of:			
Current liabilities			
Payables and accrued charges (Note 20)	135	30	165
Non-current liabilities			
Asset retirement obligations and accrued environmental costs	1,124	365	1,489

We are subject to numerous environmental requirements under federal, provincial, state and local laws in the countries in which we operate. We have gypsum stack capping, and closure and post-closure obligations through our subsidiaries, PCS Phosphate Company, Inc., in White Springs, Florida, and PCS Nitrogen, Inc., in Geismar, Louisiana, pursuant to the financial assurance regulatory requirements in those states. As at December 31, 2023, we had $492 in surety bonds and letters of credit outstanding relating to these financial assurance obligations. The recorded provisions may not necessarily reflect our obligations under these financial assurances.

In millions of US dollars unless otherwise noted

Note 23 | Share capital

Authorized

We are authorized to issue an unlimited number of common shares without par value and an unlimited number of preferred shares. The common shares are not redeemable or convertible. The preferred shares may be issued in one or more series with rights and conditions to be determined by the Board of Directors.

Share repurchase programs

	Commencement date	Expiry	Maximum shares for repurchase	Maximum shares for repurchase (%)	Number of shares repurchased
2021 Normal Course Issuer Bid	March 1, 2021	February 28, 2022	28,468,448	5	22,186,395
2022 Normal Course Issuer Bid [1]	March 1, 2022	February 7, 2023	55,111,110	10	55,111,110
2023 Normal Course Issuer Bid	March 1, 2023	February 29, 2024	24,962,194	5	5,375,397
2024 Normal Course Issuer Bid [2]	March 1, 2024	February 28, 2025	24,728,159	5	–

1 The original expiry date was February 28, 2023, but we acquired the maximum aggregate number of common shares allowable on February 7, 2023.
2 On February 21, 2024, our Board of Directors approved a share repurchase program. The 2024 normal course issuer bid, which is subject to acceptance by the Toronto Stock Exchange, will expire earlier than the date above if we acquire the maximum number of common shares allowable or otherwise decide not to make any further repurchases.

Purchases under the normal course issuer bids were, or may be, made through open market purchases at market prices as well as by other means permitted by applicable securities regulatory authorities, including private agreements.

Summary of share repurchases	2023	2022
Number of common shares repurchased for cancellation	13,378,189	53,312,559
Average price per share (US dollars)	74.73	84.34
Total cost	1,000	4,496

Dividends declared

During 2023, we declared dividends of $2.12 (2022 – $1.92). On February 21, 2024, our Board of Directors declared and increased our quarterly dividend to $0.54 per share payable on April 11, 2024, to shareholders of record on March 28, 2024. The total estimated dividend to be paid is $265.

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Note 24 | Capital management

Our capital allocation policy prioritizes safe and reliable operations, a healthy balance sheet, a sustainable dividend to shareholders, and a strategy to allocate remaining cash flow that maximizes shareholder value.

We include total debt, adjusted total debt, adjusted net debt and shareholders' equity as components of our capital structure. We monitor our capital structure and, based on changes in economic conditions, may adjust the structure by adjusting the amount of dividends paid to shareholders, repurchasing shares, issuing new shares, issuing new debt or retiring existing debt.

We have access to the capital markets through our base shelf prospectus. We use a combination of short-term and long-term debt to finance our operations. We typically pay floating rates of interest on short-term debt and credit facilities, and fixed rates on senior notes and debentures.

We monitor the following measures to evaluate our ability to service debt, make strategic investments and ensure we are in compliance with our debt covenants:

	2023	2022
Adjusted net debt to adjusted EBITDA	1.9	0.9
Adjusted EBITDA to adjusted finance costs	7.3	21.6
Debt to capital (calculated as adjusted total debt to adjusted capital) (Limit: 0.65 : 1.00)	0.33 : 1.00	0.32 : 1.00

Adjusted EBITDA is calculated in Note 3, while the calculations of the remaining components included in the above ratios are set out in the following tables:

	2023	2022
Short-term debt	1,815	2,142
Current portion of long-term debt	512	542
Current portion of lease liabilities	327	305
Long-term debt	8,913	8,040
Lease liabilities	999	899
Total debt	12,566	11,928
Letters of credit – financial	94	97
Adjusted total debt	12,660	12,025

In millions of US dollars unless otherwise noted

	2023	2022
Total debt	12,566	11,928
Cash and cash equivalents	(941)	(901)
Net unamortized fair value adjustments	(294)	(310)
Adjusted net debt	11,331	10,717

	2023	2022
Total shareholders' equity	25,201	25,863
Adjusted total debt	12,660	12,025
Adjusted capital	37,861	37,888

	2023	2022
Finance costs	793	563
Unwinding of discount on asset retirement obligations	(33)	(29)
Borrowing costs capitalized to property, plant and equipment	71	37
Interest on net defined benefit pension and other post-retirement plan obligations	(5)	(8)
Adjusted finance costs	826	563

In 2022, we filed a base shelf prospectus in Canada and the US qualifying the issuance of up to $5 billion of common shares, debt securities and other securities during a period of 25 months from March 11, 2022. In 2023 and 2022, we issued senior notes of $1.5 billion and $1 billion, respectively, pursuant to the base shelf prospectus and the applicable prospectus supplement. Refer to Note 18 for details.

Note 25 | Business combinations

	Casa do Adubo S.A. ("Casa do Adubo")	Other acquisitions
Acquisition date	October 1, 2022	Various
Purchase price, net of cash and cash equivalents acquired, and amounts held in escrow	$268 On the acquisition date, we acquired 100% of the issued and outstanding Casa do Adubo stock.	$153 (preliminary) (2022 – $176)
Goodwill and expected benefits of acquisitions	$184 – Goodwill was fully impaired as part of the impairment recorded to the Retail – South America group of CGUs (Note 14).	$126 (preliminary) (2022 – $55)
	The expected benefits of the acquisitions resulting in goodwill include: – synergies from expected reduction in operating costs – wider distribution channel for selling products of acquired businesses – a larger assembled workforce – potential increase in customer base – enhanced ability to innovate	
Description	An agriculture retailer in Brazil with 39 retail locations and 10 distribution centers. This acquisition is aligned with our disciplined approach to capital allocation and sustainability commitments, as we continue to expand our presence in Brazil.	2023 – 23 Retail locations related to various agricultural services (2022 – 43 Retail locations related to various agricultural services and one wholesale warehouse location)

In millions of US dollars unless otherwise noted

We allocated the following values to the acquired assets and assumed liabilities based upon fair values at their respective acquisition date:

	2023	2022	
	Other acquisitions[1]	Casa do Adubo final fair value	Other acquisitions[1]
Current assets	17	275[2]	116
Goodwill	126	184	55
Other non-current assets	(2)	133	131
Total assets	141	592	302
Current liabilities	20	160	74
Other non-current liabilities	2	116	42
Total liabilities	22	276	116
Non-controlling interest	(8)	–	–
Total consideration	127	316	186
Amounts held in escrow	26	(48)	(10)
Total consideration, net of cash and cash equivalents acquired, and amounts held in escrow	153	268	176

1 Includes preliminary values for current year acquisitions and finalization of measurement period adjustments for prior year acquisitions.
2 Includes receivables from customers with gross contractual amounts of $169.

We have completed our assessment of identifying and measuring all the assets acquired and liabilities assumed relating to our Casa do Adubo acquisition. This assessment included a thorough review of all internal and external sources of information available on circumstances that existed at the acquisition date, engagement of independent valuation experts, and final agreement of the purchase price with no material changes from the preliminary fair value as disclosed in the 2022 annual consolidated financial statements. For certain other acquisitions, we finalized the purchase price with no material change to the fair values disclosed in prior periods. Refer to Note 30 for details of our valuation technique and judgments applied.

Note 26 | Commitments

	Principal portion and estimated interest					
December 31, 2023	Lease liabilities	Long-term debt	Purchase commitments	Capital commitments	Other commitments	Total
Within 1 year	368	966	938	153	188	2,613
1 to 3 years	484	2,324	249	19	221	3,297
3 to 5 years	222	1,556	57	–	149	1,984
Over 5 years	451	10,493	106	–	157	11,207
Total	1,525	15,339	1,350	172	715	19,101

Purchase commitments

In 2023, we renewed our natural gas purchase agreement in Trinidad. The agreement is a minimum take or pay arrangement providing for approximately 75 percent of the expected requirements of the Trinidad ammonia complex and provides for prices that vary primarily with benchmark ammonia prices and annual escalating floor prices. The commitments included in the foregoing table are based on floor prices and minimum purchase quantities.

In millions of US dollars unless otherwise noted

Profertil has various natural gas contracts denominated in US dollars that expire in 2024 and 2028 and account for virtually all of Profertil's natural gas requirements. YPF S.A., our joint venture partner in Profertil, supplies approximately 70 percent of the natural gas under these contracts.

In 2023, we entered into natural gas pipeline transportation agreements at our Geismar plant, the latest of which expires in 2033 and accounts for approximately 90 percent of the expected natural gas requirements in Geismar.

The Carseland facility has a power cogeneration agreement expiring on December 31, 2026, which provides 60 megawatt-hours of power per hour. The price for the power is based on a fixed charge adjusted for inflation and a variable charge based on the cost of natural gas provided to the facility for power generation.

Agreements for the purchase of sulfur for use in production of phosphoric acid provide for specified purchase quantities and prices based on market rates at the time of delivery. Commitments included in the foregoing table are based on expected contract prices.

Other commitments
Other commitments consist principally of pipeline capacity, technology service contracts, managed services contracts, throughput and various rail contracts, the latest of which expires in 2036, and mineral lease commitments, the latest of which expires in 2033.

Note 27 | Guarantees

In the normal course of business, we provide indemnification agreements to counterparties in transactions such as purchase and sale contracts, service agreements, director/officer contracts, and leasing transactions. The terms of these indemnification agreements

- may require us to compensate counterparties for costs incurred as a result of various events, including environmental liabilities and changes in (or in the interpretation of) laws and regulations, or as a result of litigation claims or statutory sanctions that may be suffered by a counterparty as a consequence of the transaction;
- will vary based upon the contract, the nature of which prevents us from making a reasonable estimate of the maximum potential amount that we could be required to pay to counterparties; and
- have not historically resulted in any significant payments by Nutrien and, as at December 31, 2023, no amounts have been accrued in the consolidated financial statements (except for accruals relating to certain underlying liabilities).

We directly guarantee our share of certain commitments of Canpotex (such as railcar leases) under certain agreements with third parties. We would be required to perform on these guarantees in the event of default by the investee. No material loss is anticipated by reason of such agreements and guarantees.

Note 28 | Related party transactions

Sales and purchases of goods
We sell potash outside Canada and the US exclusively through Canpotex. Canpotex sells potash to buyers, including Nutrien, in export markets pursuant to term and spot contracts at agreed upon prices. Our total revenue is recognized at the amount received from Canpotex representing proceeds from their sale of potash, less net costs of Canpotex. Sales to Canpotex are shown in Note 3. The receivable outstanding from Canpotex is shown in Note 11 and arose from sale transactions described above. It is unsecured and bears no interest. Any credit losses held against this receivable are expected to be negligible. Purchases from Canpotex for the year ended 2023 were $92 (2022 – $415) and the amount payable to Canpotex is shown in Note 20.

Key management personnel compensation and transactions with post-employment benefit plans

	2023	2022
Salaries and other short-term benefits	10	13
Share-based compensation	(7)	18
Post-employment benefits	2	3
Termination benefits	2	10
	7	44

Disclosures related to our post-employment benefit plans are shown in Note 21.

Note 29 | Contingencies and other matters

Accounting estimates and judgments

The following judgments are required to determine our exposure to possible losses and gains related to environmental matters and other various claims and lawsuits pending:

- prediction of the outcome of uncertain events (i.e., being virtually certain, probable, remote or undeterminable);
- determination of whether recognition or disclosure in the consolidated financial statements is required; and
- estimation of potential financial effects.

Where no amounts are recognized, such amounts are contingent and disclosure may be appropriate. While the amount disclosed in the consolidated financial statements may not be material, the potential for large liabilities exists and, therefore, these estimates could have a material impact on our consolidated financial statements.

Supporting information

Canpotex

Nutrien is a shareholder in Canpotex, which markets Canadian potash outside of Canada and the US. Should any operating losses or other liabilities be incurred by Canpotex, the shareholders have contractually agreed to reimburse it in proportion to each shareholder's productive capacity. Through December 31, 2023, we are not aware of any operating losses or other liabilities.

Mining risk

The risk of underground water inflows and other underground risks is insured on a limited basis, subject to insurance market availability. Through December 31, 2023, we are not aware of any material losses or other liabilities that we have not accrued for.

Environmental remediation, legal and other matters

We are engaged in ongoing site assessment and/or remediation activities at a number of facilities and sites. Anticipated costs associated with these matters are added to accrued environmental costs in the manner described in Note 22.

We have established provisions for environmental site assessment and/or remediation matters to the extent that we consider expenses associated with those matters likely to be incurred. Except for the uncertainties described below, we do not believe that our future obligations with respect to these matters are reasonably likely to have a material adverse effect on our consolidated financial statements.

In millions of US dollars unless otherwise noted

Legal matters with significant uncertainties include the following:

- The United States Environmental Protection Agency ("US EPA") has an ongoing enforcement initiative directed at the phosphate industry related to the scope of an exemption for mineral processing wastes under the US Resource Conservation and Recovery Act ("RCRA"). This initiative affects the Conda Phosphate plant previously owned by Nu-West Industries, Inc. ("Nu-West"), a wholly owned subsidiary of Nutrien (Canada) Holdings ULC, and the Nutrien phosphoric acid facilities in Aurora, North Carolina; Geismar, Louisiana; and White Springs, Florida. Nutrien facilities received US EPA notices of violation ("NOVs") for alleged violations of the RCRA and various other environmental laws. Notwithstanding the sale of the Conda Phosphate operations in January 2018, Nu-West remains responsible for certain environmental liabilities attributable to its historic activities and for resolution of the NOVs. The facilities have been and continue to be involved in ongoing discussions with the US EPA, the US Department of Justice and the related state agencies to resolve these matters, with one such settlement being reached for the Geismar facility. The Geismar consent decree was entered on October 19, 2022, and resolved the allegations associated with the historic phosphoric acid operations at that facility. Due to the nature of the allegations at the other facilities, we are uncertain as to how the matters will be resolved. Based on settlements with other members of the phosphate industry and the Geismar consent decree, we expect that a resolution could involve any or all of the following: 1) penalties, which we currently believe will not be material; 2) modification of certain operating practices; 3) capital improvement projects; 4) providing financial assurance for the future closure, maintenance and monitoring costs for the phosphogypsum stack system; and 5) addressing findings resulting from the RCRA section 3013 site investigations.

- We operate in countries that are parties to the Paris Agreement adopted in December 2015 pursuant to the United Nations Framework Convention on Climate Change. Each country that is a party to the Paris Agreement submitted an Intended Nationally Determined Contribution ("INDC") towards the control of greenhouse gas emissions. The impacts on our operations of these INDCs and other national and local efforts to limit or tax greenhouse gas emissions cannot be determined with any certainty at this time.

In addition, various other claims and lawsuits are pending against the Company in the ordinary course of business. While it is not possible to determine the ultimate outcome of such actions at this time, and inherent uncertainties exist in predicting such outcomes, we believe that the ultimate resolution of such actions is not reasonably likely to have a material adverse effect on our consolidated financial statements.

The breadth of our operations and the global complexity of tax regulations require assessments of uncertainties and judgments in estimating the taxes we will ultimately pay. The final taxes paid are dependent upon many factors, including negotiations with taxing authorities in various jurisdictions, outcomes of tax litigation, and resolution of disputes arising from federal, provincial, state and local tax audits. The resolution of these uncertainties and the associated final taxes may result in adjustments to our tax assets and tax liabilities.

We own facilities that have been either permanently or indefinitely shut down. We expect to incur nominal annual expenditures for site security and other maintenance costs at some of these facilities. Should the facilities be dismantled, certain other shutdown-related costs may be incurred. Such costs are not expected to have a material adverse effect on our consolidated financial statements and would be recognized and recorded in the period in which they are incurred.

Note 30 | Accounting policies, estimates and judgments

The following discusses the significant accounting policies, estimates, judgments and assumptions that we have adopted and applied and how they affect the amounts reported in the consolidated financial statements. Certain of our policies involve accounting estimates and judgments because they require us to make subjective or complex judgments about matters that are inherently uncertain and because of the likelihood that materially different amounts could be reported under different conditions or using different assumptions.

Basis of consolidation

Principal (wholly owned) operating subsidiaries	Location	Principal activity
Potash Corporation of Saskatchewan Inc.	Canada	Mining and/or processing of crop nutrients and corporate functions
Nutrien (Canada) Holdings ULC	Canada	Manufacturer and distributor of crop nutrients and corporate functions
Agrium Canada Partnership	Canada	Manufacturer and distributor of crop nutrients
Agrium Potash Ltd.	Canada	
Nutrien US LLC	US	
Cominco Fertilizer Partnership	US	
Loveland Products Inc.	US	
Nutrien Ag Solutions (Canada) Inc.	Canada	Crop input retailer
Nutrien Ag Solutions, Inc.	US	
Nutrien Ag Solutions Limited	Australia	
PCS Nitrogen Fertilizer, L.P.	US	Producer of nitrogen products
PCS Nitrogen Trinidad Limited	Trinidad	
PCS Phosphate Company, Inc.	US	Mining and/or processing of phosphate products
PCS Sales (USA), Inc.	US	Marketing and sales of the Company's products
Nutrien Financial US LLC	US	Provide financing to customers

Climate change

Our Feeding the Future Plan includes sustainability-related commitments to help address our key climate-related risks related to climate change and to reduce our carbon footprint. Nutrien continues to execute our sustainability strategy and deliver on our action plan and monitor the development of sustainability frameworks and regulatory initiatives. We recognize that these developments could further impact our accounting estimates and judgments including, but not limited to, assessment of our asset useful lives, impairment of other long-lived assets, and asset retirement obligations and accrued environmental costs. We have monitored and will continue to monitor these developments as they affect our consolidated financial statements.

Revenue

Transfer of control for sale of goods	Transfer of control for sale of services
At the point in time when the product is – purchased at our Retail farm center, – delivered and accepted by customers at their premises, or – loaded for shipping.	Over time as the promised service is rendered.

Judgment is used to determine whether we are acting as principal or agent by evaluating who
- has the primary responsibility for fulfilling the promised good;
- bears the inventory risk including if the vendor has the right to have its product returned on demand; and
- has discretion for establishing the price.

For transactions in which we act as an agent rather than the principal, revenue is recognized net of any commissions earned. The related commissions are recognized as the sales occur or as unconditional contracts are signed.

We recognize revenue on sales to Canpotex (as described in Note 28) when there is a transfer of control, either at the time the product is loaded for shipping or delivered, depending on the terms of the contract. Sales revenue is recognized using a provisional price at the time control is transferred to Canpotex, with the final pricing determined upon Canpotex's final sale to a third party (generally between one and three months from date of sale to Canpotex).

Our sales revenue relating to our Potash, Nitrogen and Phosphate segments is generally recorded and measured based on the "freight on board" mine, plant, warehouse or terminal price specified in the contract (except for certain vessel sales or specific product sales that are shipped and recorded on a delivered basis), which reflects the consideration we expect to be entitled to in exchange for the goods or services, adjusted for any variable consideration (e.g., any trade discounts or estimated volume rebates). Our customer contracts may provide certain product quality specification guarantees but do not generally provide for refunds or returns.

Due to the nature of goods and services sold, any single estimate would have only a negligible impact on revenue.

As the expected period between when control over a promised good or service is transferred and when the customer pays for that good or service is generally less than 12 months, we apply the practical expedient as provided in IFRS 15, "Revenue from Contracts with Customers," and do not adjust the promised amount of consideration for the effects of financing.

Intersegment sales are made under terms that approximate market value.

Seasonality in our business results from increased demand for products during planting season. Crop input sales are generally higher in the spring and fall application seasons. Crop input inventories are normally accumulated leading up to each application season. Our cash collections generally occur after the application season is complete, while customer prepayments made to us are typically concentrated in December and January and inventory prepayments paid to our suppliers are typically concentrated in the period from November to January. Feed and industrial sales are more evenly distributed throughout the year.

Share-based compensation
Estimation involves determining
- stock option-pricing model assumptions as described in the weighted average assumptions table in Note 5;
- forfeiture rate for options granted based on past experience and future expectations, and adjusted upon actual vesting;
- projected outcome of performance conditions for PSUs, including our return on invested capital compared to Nutrien's weighted average cost of capital, and including the relative ranking of our total shareholder return, including expected dividends, compared with a specified peer group using a Monte Carlo simulation option-pricing model; and
- the number of dividend equivalent units expected to be earned.

Income taxes
Taxation on earnings (loss) is composed of current and deferred income tax. Taxation is recognized in the statements of earnings unless it relates to items recognized either in OCI or directly in shareholders' equity.

Current income tax	Deferred income tax
– is calculated using rates enacted or substantively enacted at the dates of the consolidated balance sheets in the countries where our subsidiaries and equity-accounted investees operate and generate taxable earnings.	– is determined using tax rates that have been enacted or substantively enacted by the dates of the consolidated balance sheets and are expected to apply when the related deferred income tax asset is realized or the deferred income tax liability is settled.

The realized and unrealized excess tax benefits from share-based compensation arrangements are recognized in contributed surplus as current and deferred tax, respectively.

The final taxes paid, and potential adjustments to tax assets and liabilities, are dependent upon many factors including
- negotiations with taxation authorities in various jurisdictions;
- outcomes of tax litigation; and
- resolution of disputes arising from federal, provincial, state and local tax audits.

Deferred income tax is not accounted for
- with respect to investments in subsidiaries and equity-accounted investees where we are able to control the reversal of the temporary difference and that difference is not expected to reverse in the foreseeable future; and
- if arising from initial recognition of an asset or liability in a transaction, other than a business combination, that at the time of the transaction affects neither accounting nor taxable profit or loss.

Deferred tax assets are
- recognized to the extent it is probable future taxable profit will be available to use deductible temporary differences and could be reduced if projected earnings are not achieved or increased if earnings previously not projected become probable; and
- reviewed at each balance sheet date and amended to the extent that it is no longer probable that the related tax benefit will be realized.

As provided in the amendments to International Accounting Standards ("IAS") 12, we apply the mandatory exception to recognize and disclose information about deferred tax assets and liabilities related to Pillar Two income taxes. The mandatory exception has been applied retrospectively, with no material impact on our consolidated financial statements.

Financial instruments

Financial instruments are classified and measured as follows based on the objective of the business model for managing the instrument or group of instruments and the contractual terms of the cash flows.

Fair value classification	FVTPL	FVTOCI	Amortized cost
Instrument type	Cash and cash equivalents, derivatives, and certain equity investments not held for trading	Certain equity investments not held for trading for which an irrevocable election was made at initial recognition	Receivables, short-term debt, payables and accrued charges, long-term debt, lease liabilities, and other long-term debt instruments

Financial instruments are recognized at trade date when we commit to purchase or sell the asset.

Derivatives are used to lock in exchange rates. For designated and qualified cash flow hedges
- the effective portion of the change in the fair value of the derivative is accumulated in OCI;
- when the hedged forecast transaction occurs, the related gain or loss is removed from AOCI and included in the cost of inventory or property, plant and equipment;
- the hedging gain or loss included in the cost of inventory is recognized in earnings when the product containing the hedged item is sold or becomes impaired; and
- the ineffective portions of hedges are recorded in net earnings in the current period.

We assess whether our derivative hedging transactions are expected to be or were highly effective, both at the hedge's inception and on an ongoing basis, in offsetting changes in fair values of hedged items.

Hedging transaction	Measurement of ineffectiveness	Potential sources of ineffectiveness
Foreign exchange	Comparison of the cumulative changes in fair value and the cumulative change in the fair value of a hypothetical derivative with terms based on the hedged forecast cash flows	Changes in – timing or amounts of forecasted cash flows – embedded optionality – our credit risk or the credit risk of a counterparty

Financial assets and financial liabilities are offset, and the net amount is presented in the consolidated balance sheets when we
- currently have a legally enforceable right to offset the recognized amounts; and
- intend either to settle on a net basis, or to realize the assets and settle the liabilities simultaneously.

Fair value measurements

Estimated fair values for financial instruments are designed to approximate amounts for which the instruments could be exchanged in a current arm's length transaction between knowledgeable, willing parties. The valuation policies and procedures for financial reporting purposes are determined by our finance department.

Fair value measurements are categorized into different levels within a fair value hierarchy based on the degree to which the lowest level inputs are observable and their significance:

Level 1	Level 2	Level 3
Unadjusted quoted prices (in active markets accessible at the measurement date for identical assets or liabilities)	Quoted prices (in markets that are not active or based on inputs that are observable for substantially the full term of the asset or liability)	Prices or valuation techniques that require inputs that are both unobservable and significant to the overall measurement

Fair value estimates
- are at a point in time and may change in subsequent reporting periods due to market conditions or other factors;
- can be determined using multiple methods, which can cause values (or a range of reasonable values) to differ; and
- may require assumptions about costs/prices over time, discount and inflation rates, defaults, and other relevant variables.

Inventories

Costs are allocated to inventory using the weighted average cost method.

Net realizable value is based on:

Products and raw materials	Materials and supplies
– selling price of the finished product (in ordinary course of business) less the estimated costs of completion and estimated costs to make the sale	– replacement cost

Inventories are valued monthly. Various factors impact our estimates of net realizable value, including inventory levels, forecasted prices of key production inputs, global nutrient capacities, crop price trends, and changes in regulations and standards employed.

Vendors may offer various incentives to purchase products for resale. Vendor rebates and prepay discounts are accounted for as a reduction of the prices of the suppliers' products. Rebates based on the amount of materials purchased reduce cost of goods sold as inventory is sold. Rebates earned based on sales volumes of products are offset to cost of goods sold.

Rebates that are probable and can be reasonably estimated are accrued. Rebates that are not probable or estimable are accrued when certain milestones are achieved.

Estimation of rebates can be complex in nature as vendor arrangements are diverse. The amount of the accrual is determined by analyzing and reviewing historical trends to apply negotiated rates to estimated and actual purchase volumes. Estimated amounts accrued throughout the year could also be impacted if actual purchase volumes differ from projected volumes.

Property, plant and equipment

	Owned	Right-of-use (leased)
Description	– majority of our tangible assets are buildings, machinery and equipment used to produce or distribute our products and render our services	– primarily include railcars, marine vessels, real estate and mobile equipment

	Owned	Right-of-use (leased)
Measurement	– cost, which includes capitalized borrowing costs, less accumulated depreciation and any accumulated impairment losses – cost of major inspections and overhauls is capitalized – maintenance and repair expenditures that do not improve or extend productive life are expensed in the period incurred	– cost less accumulated depreciation and any accumulated impairment losses – lease payments are allocated between finance costs and a reduction of the liability
Depreciation method	– certain property, plant and equipment directly related to our Potash, Nitrogen and Phosphate segments uses units-of-production based on the shorter of estimates of reserves or service lives – pre-stripping costs uses units-of-production over the ore mined from the mineable acreage stripped – remaining assets uses straight-line	– straight-line over the shorter of the asset's useful life and the lease term
	Estimated useful lives, expected patterns of consumption, depreciation method and residual values are reviewed at least annually.	
Judgment/practical expedients	Judgment is required in determining – costs, including income or expenses derived from an asset under construction, that are eligible for capitalization; – timing to cease cost capitalization, generally when the asset is capable of operating in the manner intended by management, but also considering the circumstances and the industry in which the asset is to be operated, normally predetermined by management with reference to such factors as productive capacity; – the appropriate level of componentization (for individual components for which different depreciation methods or rates are appropriate); – repairs and maintenance that qualify as major inspections and overhauls; and – useful life over which such costs should be depreciated, which may be impacted by changes in our strategy, process or operations as a result of climate-change initiatives.	Judgment is required to determine whether a contract or arrangement includes a lease and if it is reasonably certain that an extension option will be exercised. We seek to maximize operational flexibility in managing our leasing activities by including extension options when negotiating new leases. Extension options are exercisable at our option and not by the lessors. In determining if a renewal period should be included in the lease term, we consider all relevant factors that create an economic incentive for us to exercise a renewal, including – the location of the asset and the availability of suitable alternatives, – the significance of the asset to operations, and – our business strategy. Estimation is used to determine the useful lives of ROU assets, the lease term and the appropriate discount rate applied to the lease payments to calculate the lease liability.
	Uncertainties are inherent in estimating reserve quantities, particularly as they relate to assumptions regarding future prices, the geology of our mines, the mining methods used, and the related costs incurred to develop and mine reserves. Changes in these assumptions could result in material adjustments to reserve estimates, which could result in impairments or changes to depreciation expense in future periods.	We have chosen to – include the use of a single discount rate for a portfolio of leases with reasonably similar characteristics, – not separate non-lease components and instead to account for lease and non-lease components as a single arrangement, and – use exemptions for short-term and low-value leases which allow payments to be expensed as incurred.
Other	Not applicable.	Lease agreements do not contain significant covenants; however, leased assets may be used as security for lease liabilities and other borrowings.

Goodwill and intangible assets

Goodwill is carried at cost less any accumulated impairment losses, is not amortized, and represents the excess of the cost of an acquisition over the fair value of the Company's share of the net identifiable assets of the acquired subsidiary at the date of acquisition. Goodwill is allocated to a CGU or group of CGUs for impairment testing based on the level at which it is monitored by management and not at a level higher than an operating segment. The allocation is made to the CGU or group of CGUs expected to benefit from the business combination in which the goodwill arose.

Intangible assets are generally measured at cost less accumulated amortization and any accumulated impairment losses. Accumulated amortization is calculated on a straight-line basis over the asset's useful life. We use judgment to determine which expenditures are eligible for capitalization as intangible assets. Costs incurred internally from researching and developing a product are expensed as incurred until technological feasibility is established, at which time the costs are capitalized until the product is available for its intended use. Judgment is required in determining when technological feasibility of a product is established. Intangible assets with finite lives are amortized on a straight-line basis over their estimated useful lives. At least annually, the useful lives are reviewed and adjusted if appropriate.

Impairment of long-lived assets

To assess impairment, assets are grouped at the smallest levels for which there are separately identifiable cash inflows that are largely independent of the cash inflows from other assets or groups of assets (this can be at the asset or CGU level).

At the end of each reporting period, we review conditions to determine whether there is any indication that an impairment exists that could potentially impact the carrying amounts of both our long-lived assets to be held and used (including property, plant and equipment, and investments), and our goodwill and intangible assets. When such indicators exist, impairment testing is performed. Additionally, goodwill is tested at least annually on October 1.

We review, at each reporting period, for possible reversal of the impairment for non-financial assets, other than goodwill.

Estimates and judgment involve
- identifying the appropriate asset, group of assets, CGU or group of CGUs;
- determining the appropriate discount rate for assessing the recoverable amount;
- making assumptions about future sales, market conditions, terminal growth rates and cash flow forecasts over the long-term life of the assets or CGUs; and
- evaluating impacts of climate change to our strategy, processes and operations.

We cannot predict if an event that triggers impairment or a reversal of impairment will occur, when it will occur or how it will affect reported asset amounts. Asset impairment amounts previously recorded could be affected if different assumptions were used or if market and other conditions change. Such changes could result in non-cash charges materially affecting our consolidated financial statements.

Equity-accounted investments

For equity-accounted investments reduced to zero, we do not eliminate our share of the unrealized earnings. If the investee earns a profit in the subsequent period, we then recognize our share of the earnings only after adjusting for the unrealized earnings that were not previously eliminated.

Pension and other post-retirement benefits

When a plan amendment occurs before a settlement, we recognize past service cost before any gain or loss on settlement.

Our discount rate assumptions are impacted by
- the weighted average interest rate at which each pension and other post-retirement plan liability could be effectively settled at the measurement date;
- country specific rates; and
- the use of a yield curve approach based on the respective plans' demographics, expected future pension benefits and medical claims. Payments are measured and discounted to determine the present value of the expected future cash flows. The cash flows are discounted using yields on high-quality AA-rated non-callable bonds with cash flows of similar timing where there is a deep market for such bonds. Where we do not believe there is a deep market for such bonds (such as for terms in excess of 10 years in Canada), the cash flows are discounted using a yield curve derived from yields on provincial bonds rated AA or better to which a spread adjustment is added to reflect the additional risk of corporate bonds.

Net actuarial gains or loss incurred during the period for defined benefit plans are closed out to retained earnings at each period-end.

Asset retirement obligations and accrued environmental costs

Asset retirement obligations and accrued environmental costs include

- reclamation and restoration costs at our potash and phosphate mining operations, including management of materials generated by mining and mineral processing, such as various mine tailings and gypsum;
- land reclamation and revegetation programs;
- decommissioning of underground and surface operating facilities;
- general clean-up activities aimed at returning the areas to an environmentally acceptable condition; and
- post-closure care and maintenance.

We consider the following factors as we estimate our provisions:

- environmental laws and regulations and interpretations by regulatory authorities, including updates on climate change, could change or circumstances affecting our operations could change, either of which could result in significant changes to current plans;
- the nature, extent and timing of current and proposed reclamation and closure techniques in view of present environmental laws and regulations;
- appropriate technical resources, including outside consultants, assist us in developing specific site closure and post-closure plans in accordance with the jurisdiction requirements; and
- timing of settlement of the obligations, which is typically correlated with mine life estimates except for certain land reclamation programs.

It is reasonably possible that the ultimate costs could change in the future and that changes to these estimates could have a material effect on our consolidated financial statements. We review our estimates for any changes in assumptions at the end of each reporting period.

We recognized contingent liabilities related to our business combinations or acquisitions, which represent additional environmental costs that are present obligations although cash outflows of resources are not probable. These contingent liabilities are subsequently measured at the higher of the amount initially recognized and the amount that would be recognized if the liability becomes probable.

Share capital

Common shares are classified as equity. Incremental costs directly attributable to the issuance of common shares are recognized as a deduction from equity, net of any tax effects. When we repurchase our own common shares, share capital is reduced by the average carrying value of the shares repurchased. The excess of the purchase price over the average carrying value is recognized as a deduction from retained earnings. If the average carrying value of the shares repurchased is less than the average carrying value of the shares in share capital, the excess is recognized as an addition to share capital. Shares are cancelled upon repurchase.

Business combinations
Purchase price allocation involves judgment in identifying assets acquired and liabilities assumed, and estimation of their fair values. Key assumptions include discount rates and revenue growth rates specific to the acquired assets or liabilities assumed. We perform a thorough review of all internal and external sources of information available based on circumstances that exist at the acquisition date. We also engage independent valuation experts on certain acquisitions to assist in determining the fair value of certain assets acquired and liabilities assumed and related deferred income tax impacts. To determine fair values, we generally use the following valuation techniques:

Account	Valuation technique and judgments applied
Property, plant and equipment	Market approach for land and certain types of personal property: sales comparison that measures the value of an asset through an analysis of sales and offerings of comparable assets. Replacement costs for all other depreciable property, plant and equipment: measures the value of an asset by estimating the costs to acquire or construct comparable assets and adjusts for age and condition of the asset.
Intangible assets	Income approach – multi-period excess earnings method: measures the value of an asset based on the present value of the incremental after-tax cash flows attributable to the asset after deducting contributory asset charges ("CACs"). Allocation of CACs is a matter of judgment and based on the nature of the acquired businesses' operations and historical trends. We consider several factors in determining the fair value of customer relationships, such as customers' relationships with the acquired company and its employees, the segmentation of customers, historical customer attrition rates, and revenue growth.
Other provisions and contingent liabilities	Decision-tree approach of future costs and a risk premium to capture the compensation sought by risk-averse market participants for bearing the uncertainty inherent in the cash flows of the liability.

For each business combination, we elect to measure the non-controlling interest in the acquired entity either at fair value or at the proportionate share of the acquiree's identifiable net assets. Foreign exchange hedge gains or losses that we designated a cash flow hedge are included in the consideration. The gain or loss from the cash flow hedge is deferred in OCI and subsequently recorded as an adjustment to goodwill when the business combination occurs.

Transaction costs are recorded in integration and restructuring related costs in other (income) expenses.

Standards, amendments and interpretations effective and applied
The IASB and IFRS Interpretations Committee ("IFRIC") has issued certain standards and amendments or interpretations to existing standards that were effective, and we have applied.

In 2023, we adopted the following standards, amendments and annual improvements with no material impact on our consolidated financial statements:
- Deferred Tax related to Assets and Liabilities arising from a Single Transaction (IFRS 1, IAS 12)
- Disclosure of Accounting Policies (Amendments to IAS 1 and IFRS Practice Statement 2)
- Definition of Accounting Estimates (Amendments to IAS 8)
- IFRS 17 Insurance Contracts, including amendments
- International Tax Reform – Pillar Two Model Rules (Amendments to IAS 12) – Under Pillar Two legislation, we are liable to pay a top-up tax for differences between our Global Anti-Base Erosion ("GLoBE") effective rate and the 15 percent minimum rate. For jurisdictions where we operate that have substantially enacted the Pillar Two legislation, we have determined no material impact. We also operate in jurisdictions where Pillar Two legislation may be enacted in the future. For these jurisdictions, we have preliminarily assessed our exposure to the Pillar Two legislation if it were to come into effect and based on this assessment we believe there is no material impact.

Standards, amendments and interpretations not yet effective and not applied

The IASB and IFRIC have issued the following standards, amendments or interpretations to existing standards that were not yet effective and not applied as at December 31, 2023.

The following amendments will be adopted in 2024 and are not expected to have a material impact on our consolidated financial statements:

- Supplier Finance Arrangements (Amendments to IAS 7 and IFRS 7)
- Lease Liability in a Sale and Leaseback (Amendments to IFRS 16)
- Classification of liabilities as current or non-current (Amendments to IAS 1)
- Non-current liabilities with Covenants (Amendments to IAS 1 and IFRS Practice Statement 2)

The following amendments are being reviewed to determine the potential impact on our consolidated financial statements:

- Lack of Exchangeability (Amendments to IAS 21), effective January 1, 2025

Terms and definitions

Terms

AECO	Alberta Energy Company, Canada
ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
Argus	Argus Media group, UK
Bloomberg	Bloomberg Finance L.P., USA
Conab	The National Supply Company (CONAB) is a public company under the Ministry of Agriculture, Livestock and Food Supply – MAPA.
CME	Canadian Manufacturers & Exporters
CRU	CRU International limited, UK
ICE	Intercontinental Exchange
IFA	International Fiscal Association
IMEA	Mato Grosso Institute of Agricultural Economics
Moody's	Moody's Corporation (NYSE: MCO), USA
NYMEX	New York Mercantile Exchange, USA
NYSE	New York Stock Exchange, USA
S&P	S&P Global Inc., USA
SPGCI	S&P Global Commodity Insights
StatsCan	Statistics Canada
TTF	Title Transfer Facility
TSX	Toronto Stock Exchange, Canada
USDA	United States Department of Agriculture, USA
CAD	Canadian dollar
USD	United States dollar
AUD	Australian dollar

Scientific terms

Potash	KCl	potassium chloride, 60–63.2% K_2O (solid)
Nitrogen	CO_2	carbon dioxide
	CO_2e	carbon dioxide equivalent
	DEF	diesel exhaust fluid
	ESN®	environmentally smart nitrogen, 44% nitrogen
	NH_3	ammonia (anhydrous), 82.2% N (liquid)
	N_2O	nitrous oxide
	UAN	urea ammonium nitrate solution, 28–32% N (liquid)
Phosphate	AS	ammonium sulfate (solid)
	DAP	diammonium phosphate, 46% P_2O_5 (solid)
	MAP	monoammonium phosphate, 52% P_2O_5 (solid)
	MGA	merchant grade acid, 54% P_2O_5 (liquid)
	MST	micronized sulfur technology, P + S
	P_2O_5	diphosphorus pentoxide
	SPA	superphosphoric acid, 70% P_2O_5 (liquid)

Product measures

K_2O tonne	Measures the potassium content of products having different chemical analyses
Mmt	Million metric tonnes
MMBtu	Million British thermal units
N tonne	Measures the nitrogen content of products having different chemical analyses
P_2O_5 tonne	Measures the phosphorus content of products having different chemical analyses
Product tonne	Standard measure of the weights of all types of potash, nitrogen and phosphate products

Definitions

Brownfield	New project expanding or developing an existing facility or operation.
CCUS	Carbon capture, utilization and storage. Process by which CO_2 produced from various industrial processes is captured and either utilized for further industrial processes or transported to a permanent storage location to prevent release into the atmosphere.
Capital expenditures	Represents the sum of: sustaining capital expenditures, investing capital expenditures and mine development and pre-stripping capital expenditures. See the "Other Financial Measures" section.
Carbon offset/ inset	Carbon offsetting is a way for entities to reduce their carbon footprint by paying another entity to reduce their emissions. Carbon insetting refers to the actions taken by an organization to reduce emissions within its own supply chain.
Clean ammonia	Ammonia made with direct GHG emissions reduced by at least 90 percent compared to a conventional process, produced from hydrogen obtained using the next generation of ammonia production technology, such as auto-thermal reforming or water electrolysis with renewable power; this definition does not include end product use.
Community investment	Represents cash disbursements, matching of employee gifts and in-kind contributions of equipment, goods and services, and employee volunteerism (on corporate time).
COVID-19	COVID-19 coronavirus pandemic.
Compound annual growth rate ("CAGR")	Represents the rate of return that would be required for an investment to grow from its beginning balance to its ending balance assuming the profits were reinvested at the end of each year of the investment's lifespan.
EBITDA	Calculated as net earnings (loss) before finance costs, income taxes and depreciation and amortization.
Greenfield	New project on a previously undeveloped site.
Greenhouse gas ("GHG")	Gas that contributes to the greenhouse effect by absorbing infrared radiation.
Latin America	South America, Central America, Caribbean and Mexico.
Lost-time injury frequency	Total lost-time injuries for every 200,000 hours worked for all Nutrien employees, contractors and others on site. Calculated as the total lost-time injuries multiplied by 200,000 hours worked divided by the actual number of hours worked.
Low-carbon ammonia	Ammonia made with direct GHG emissions typically reduced by approximately 60 percent but up to 80 percent compared to a conventional process, produced by primarily using carbon capture, utilization and storage ("CCUS") or other low-emission production technologies; this definition does not include end product use.
Merger	The merger of equals transaction between PotashCorp and Agrium completed effective January 1, 2018, pursuant to which PotashCorp and Agrium combined their businesses pursuant to a statutory plan of arrangement under the Canada Business Corporations Act and became wholly owned subsidiaries of Nutrien Ltd.
North America	Canada and the US.
Offshore	All markets except Canada and the US.

Definitions

Proportion of women in senior leadership	Senior leadership is defined as director level and above. Based on permanent full-time and part-time employees.
Serious injury and fatality	A work-related fatality or life-altering injury/illness experienced by an employee or directly supervised contractor conducting work on behalf of Nutrien.
Scope 1	Direct greenhouse gas emissions produced by Nutrien owned or controlled facilities.
Scope 2	Indirect greenhouse gas emissions resulting from the generation of purchased or acquired electricity, heating, cooling and steam consumed by Nutrien owned or controlled facilities.
Scope 3	Indirect greenhouse gas emissions not included in Scope 2 emissions occurring as a consequence of the activities of Nutrien, from sources not owned or controlled by Nutrien, including both upstream and downstream emissions.
Sustainable agriculture	According to the United Nations Food and Agriculture Organization, sustainable agriculture means increasing farm productivity while protecting natural resources and enhancing grower resilience.
Sustainable agriproduct program acres	Our Carbon Program is also referred to as a Sustainable Agriproducts Program. Sustainable agriproduct acres involve agronomic solutions leading to measurable outcomes such as carbon, soil or water, with the ability to validate and verify those outcomes.
Sustainably engaged acres	Acres participating in programs that track field level data which can be analyzed for sustainability metrics and/or acres participating in sustainable agriproducts programs that incentivize growers to adopt additional sustainable practices and products resulting in quantifiable, incremental benefits which may be verified and used for reporting purposes.
Total employee turnover rate	The number of permanent employees who left the Company due to voluntary and involuntary terminations, including retirements and deaths, as a percentage of average permanent employees for the year.
Total recordable injury frequency	Total recordable injuries for every 200,000 hours worked for all Nutrien employees, contractors and others on site. Calculated as the total recordable injuries multiplied by 200,000 hours worked divided by the actual number of hours worked.

Shareholder information

Dividends

Dividend amounts paid to shareholders resident in Canada are paid in Canadian dollars, calculated based on the Bank of Canada daily average exchange rate on the dividend record date. The declaration, amount and payment date of any dividend by the Company is at the discretion of the Board of Directors and will depend on numerous factors, including compliance with applicable laws and the financial performance, debt obligations, working capital requirements and future capital requirements of Nutrien and its subsidiaries. Historically dividends have been paid in January, April, July and October approximately three weeks after record dates on the last trading day of the immediately preceding month. Registered shareholders may enroll for direct deposit by contacting Computershare Investor Services Inc., the Company's registrar and transfer agent.

Common share prices

The Company's common shares are traded on the Toronto Stock Exchange and the New York Stock Exchange. Nutrien is included in the S&P/TSX 60 and the S&P/TSX Composite indices.

Ownership

On February 22, 2024, there were 852 holders of record of the Company's common shares.

Offices

Nutrien's registered head office is:

Suite 1700, 211 19th Street East
Saskatoon, Saskatchewan
Canada S7K 5R6

We also have corporate offices at:

13131 Lake Fraser Drive SE
Calgary, Alberta
Canada T2J 7E8

5296 Harvest Lake Drive
Loveland, Colorado
US 80538

Investor relations

Investor relations department

Email investors@nutrien.com

Transfer agent

You can contact Computershare Investor Services Inc., the Company's transfer agent, as follows:

Phone **1-888-847-9773**
(toll-free within Canada and the US)
1-514-982-7555
(from any country other than Canada and the US)

By fax **1-888-453-0330**
(all countries)

By mail Computershare
100 University Drive
8th Floor, North Tower
Toronto, ON M5J 2Y1

Internet Access your registered account on the Investor Centre website:
investorcentre.com

NYSE corporate governance

The certifications required by Section 302 of the Sarbanes-Oxley Act of 2002 are filed as exhibits to our 2023 Annual Report on Form 40-F.

Iowa, US

The US Corn Belt is an area with deep fertile soils. Through the use of crop inputs and agriculture technology, from Nutrien and the industry as a whole, US corn yields have increased by more than six fold since the 1930s.

Nutrien

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